Work Implementation Plan
Aggressive Remediation Strategy

FINAL

May 2000

McClellan Air Force Base

AIR FORCE MATERIEL COMMAND

EM

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS SACRAMENTO AIR LOGISTICS CENTER (AFMC)
MCCLELLAN AIR FORCE BASE, CALIFORNIA

MEMORANDUM FOR SEE DISTRIBUTION

MAY 18 2000

FROM: SM-ALC/EMR
5050 Dudley Blvd, Suite 3
McClellan AFB CA 95652-1389

SUBJECT: Technology Demonstration – Aggressive Remediation Strategy
(DSR Rec. No. 385-5)

1. Enclosed is the final Work Implementation Plan for the development of an aggressive remediation strategy. This project is being performed by Radian International and fieldwork will be conducted in Operable Unit B south of Building 658. Comments received to the draft final Work Implementation Plan have been addressed in the draft final document.

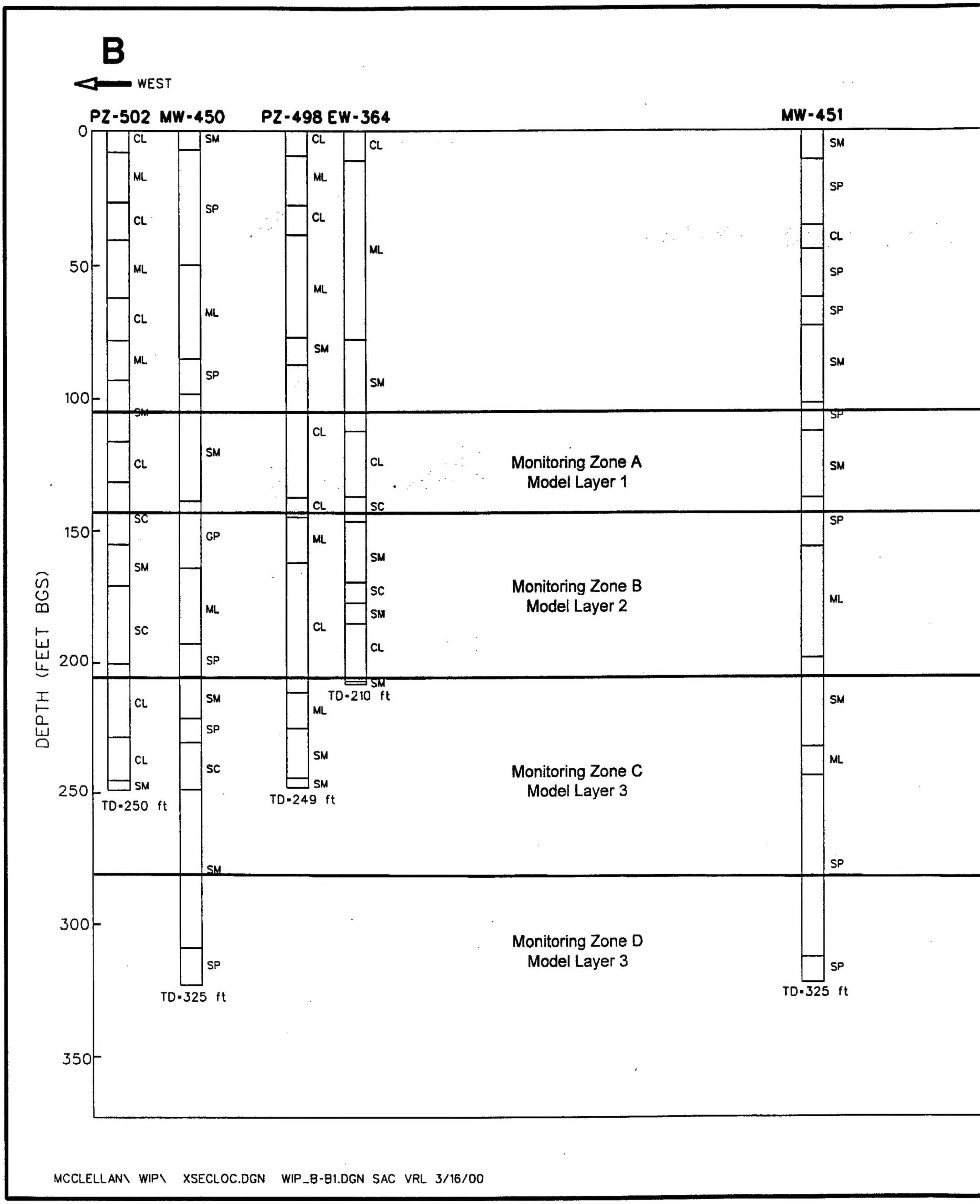
2. According to the Interagency Agreement (IAG) this is a secondary document. This document is Record Number 385-5 on the McClellan Document Deliverable Status Report with a due date of 22 May 2000.

3. If you have any questions or concerns, please contact either Mr. Timothy Chapman at (916) 643-0830 ext. 412 or Mr. Jim Lu at (916) 643-0830 ext. 466.

Philip H. Mook, Jr.
PHILIP H. MOOK, Jr., P.E.
Remedial Program Manager
Environmental Restoration Division
Environmental Management Directorate

Attachment:
Final Work Implementation Plan

cc: Admin Record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Monitoring Zone A
Model Layer 1
Monitoring Zone B
Model Layer 2
Monitoring Zone C
Model Layer 3
Monitoring Zone D
Model Layer 3
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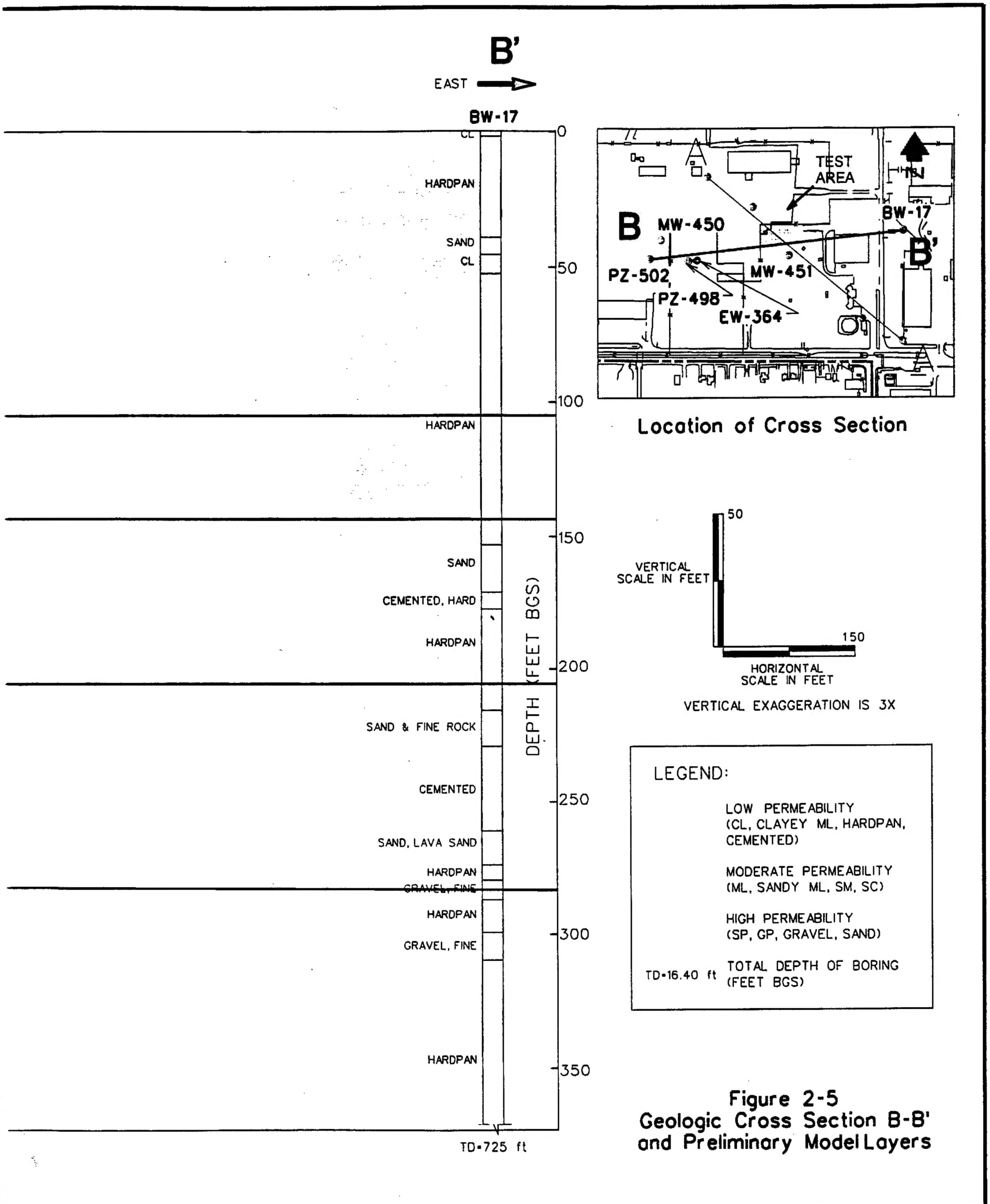

Figure 2-5
Geologic Cross Section B-B' and Preliminary Model Layers

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ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AFB	Air Force Base
AFBCA	Air Force Base Conversion Agency
AOC	Area of concern
ARCH	Air rotary casing hammer
AW	Arcade water well
BFB	Bromofluorobenzene
bgs	Below ground surface
BRAC	Base Realignment and Closure Act
BW	Base well
CAA	Clean Air Act
CCC	Calibration check compound
CCR	California Code of Regulations
CCV	Continuing calibration verification
CD-ROM	Compact disk – read only memory
CDWR	California Department of Water Resources
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfm	Cubic feet per minute
CoC	Chain of custody
CSF	Conforming storage facility
CV	Coefficient variable
CVRWQCB	Central Valley Regional Water Quality Control Board
CWA	Clean Water Act
DCA	Dichloroethane
DCE	Dichloroethene
DERP	Defense Environmental Restoration Program
DHS	Department of Health Services
$DIST_{MID}$	Distance from well bottom to midpoint of saturated well-screen interval
DO	Dissolved oxygen
DoD	Department of Defense
DQO	Data quality objective
D_{SB}	Depth to top of well screen
D_{SE}	Depth to well bottom
DTSC	Department of Toxic Substances Control
EM	Environmental Management Directorate
EMPC	Environmental Management Compliance Division
EMR	Environmental Management Restoration Division
EPA-ERT	U.S. Environmental Protection Agency-Emergency Response Team

ACRONYMS AND ABBREVIATIONS (Continued)

ERPIMS	Environmental resources program information management system
EW	Extraction well
FC	Field coordinator
FD	Field duplicate
FIFR	Federal Insecticide, Fungicide, Rodenticide Act
FS	Feasibility study
FSP	Field sampling plan
ft	Feet
GAC	Granulated activated carbon
GC/MS	Gas chromatography/mass spectrometry
GMP	Groundwater monitoring plan
gpm	Gallons per minute
GSAP	Groundwater Sampling and Analysis Program
GW	Groundwater
GWMP	Groundwater Monitoring Program
GWOU	Groundwater operable unit
GWTP	Groundwater treatment plant
H_2SO_4	Sulfuric acid
H_3PO_4	Phosphoric acid
HASP	Health and safety plan
HCl	Hydrochloric acid
HEPA	High Efficiency Particulate Arrestance
IAG	Interagency agreement
IC	Investigative cluster
ID	Identification number
IRP	Installation Restoration Program
IS	Internal standard
LCS	Laboratory control sample
LIMS	Laboratory information management system
L_{SAT}	Saturated well screen length
McAFB	McClellan Air Force Base
MCL	Maximum contaminant level
MDL	Method detection limit
METRIC	McClellan Environmental Technology Remediation Implementation Contract
min	Minutes
mL	Milliliter
MS	Matrix spike
MSA	Mine Safety Appliances
MSD	Matrix spike duplicate

ACRONYMS AND ABBREVIATIONS (Continued)

MSDS	Material safety data sheet
msl	Mean sea level
MW	Monitoring well
N	Normal
NA	Not applicable
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NETTS	National Environmental Technology Test Site
NIOSH	National Institute for Occupational Safety and Health
No.	Number
NPL	National Priorities List
NW	Northridge water well
ORP	Oxygen reduction potential
OSHA	Occupational Safety and Health Administration
OU	Operable unit
OVA	Organic vapor/acid gas
OVM	Organic vapor monitor
PARCC	Precision, accuracy, representativeness, comparability, and completeness
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethene
PEL	Permissible exposure limit
PGOURI	Preliminary groundwater operable unit remedial investigation
PID	Photoionization detector
ppbv	Parts per billion by volume
PPE	Personal protective equipment
ppm	Parts per million
PRL	Potential release location
psi	Pounds per square inch
PVC	Polyvinyl chlorine
QA	Quality assurance
QAC	Quality assurance coordinator
QAE	Quality assurance evaluator
QAO	Quality assurance objective
QAPP	Quality assurance project plan (basewide)
QC	Quality control
QL	Quantitation limit
r	Correlation coefficient
RCRA	Resource Conservation and Recovery Act
REL	Recommended exposure limit
RF	Relative response factor

ACRONYMS AND ABBREVIATIONS (Continued)

RI	Remedial investigation
ROD	Record of decision
RPD	Relative percent difference
RPM	Remedial project manager
RSD	Relative standard deviation
RT	Retention time
SA	Study area
SARA	Superfund Reauthorization Act
SDWA	Safe Drinking Water Act
SERDP	Strategic Environmental Research and Development Program
SM-ALC	Sacramento – Air Logistics Center
SMAQMD	Sacramento Metropolitan Air Quality Management District
SOP	Standard operating procedure
SPCC	System performance check compounds
SRG	Supervising rig geologist
SSHO/SEC	Site safety and health officer and site emergency coordinator
SSO	Site safety officer
SVE	Soil vapor extraction
t	Air temperature
TAAR	Technology application analysis report
t_{adj}	Adjusted air temperature
TCA	Trichloroethane
TCE	Trichloroethene
TLV	Threshold limit value
TOC	Total organic carbon
TSCA	Toxic Substances Control Act
U.S. EPA	United States Environmental Protection Agency
USC	Untied States Code
USGS	United States Geologic Survey
VOA	Volatile organic analysis
VOC	Volatile organic compound
WIP	Work implementation plan
WL	Water level
°C	Degrees Celsius
°F	Degrees Fahrenheit
%R	Percent recovery
µg/L	Micrograms per liter

FINAL
WORK IMPLEMENTATION PLAN

FOR

AGGRESSIVE REMEDIATION STRATEGY AT McCLELLAN AIR FORCE BASE

Environmental Management Directorate
Sacramento Air Logistics Center
McClellan Air Force Base, California

May 2000

NOTICE

This Work Implementation Plan (WIP) has been prepared for McClellan Air Force Base (AFB) to aid in the identification of aggressive remediation strategies at a site identified as having the longest time to cleanup in groundwater monitoring zone A. As this report relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final decision on remedial action is in the public's interest. The limited objectives of this report and the evolving knowledge of site conditions and chemical effects on the environment and on human health all must be considered when evaluating this WIP, since subsequent facts may become known that make this WIP premature or inaccurate. Acceptance of this WIP in performance of the contract under which it is prepared does not mean that the Air Force adopts the conclusions, recommendations, or other views expressed herein, which are those of the contractor only and do not necessarily reflect the official position of the Air Force.

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Radian International
10389 Old Placerville Road
Sacramento, CA 95827

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13. ABSTRACT (Maximum 200 words)

This Work Implementation Plan (WIP) report describes an aggressive remediation strategy for McClellan Air Force Base (AFB). The site chosen for evaluation was one identified as having the longest time to clean up. The aggressive remediation strategy to be evaluated includes aggressive dewatering combined with soil vapor extraction and *in situ* oxidation.

14. SUBJECT TERMS
Work Implementation Plan; Aggressive Remediation Strategy; Aggressive Dewatering; Soil Vapor Extraction; and *In Situ* Oxidation

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FINAL
WORK IMPLEMENTATION PLAN
AGGRESSIVE REMEDIATION STRATEGY
McCLELLAN AFB, CA
MAY 2000

This report was prepared by the staff of Radian International under the supervision of the undersigned registered professionals. The approaches to testing, sampling, and analysis are based upon high quality data obtained in Radian field investigations and upon information obtained from previous investigations. The approach to testing presented in the report for the *in situ* oxidation technology was directed by Robert Pedlar, R.C.E. All other sampling and measurement plans were overseen by Thomas F. Cudzilo, Ph.D.

Thomas F. Cudzilo
Thomas F. Cudzilo, Ph.D.
Certified Hydrogeologist 353

REGISTERED PROFESSIONAL ENGINEER
ROBERT C. PEDLAR
No. 33429
EXPIRES 6-30-02
CIVIL
STATE OF CALIFORNIA

Robert Pedlar, R.C.E.
California Registered Civil Engineer RCE33429

1.0 INTRODUCTION AND BACKGROUND

This work implementation plan (WIP) addresses testing of an aggressive dewatering strategy at McClellan Air Force Base (AFB), a National Environmental Technology Test Site (NETTS).

1.1 PROGRAM OVERVIEW

McClellan AFB has implemented an aggressive program to find more cost-effective environmental cleanup technologies. To this end, the McClellan AFB Environmental Management Directorate (EM), Technology Integration Group was created to identify and evaluate emerging or innovative environmental remediation and monitoring technologies. As part of the McClellan AFB remediation program, the Air Force Base Conversion Agency (AFBCA) provides funding to evaluate technologies (*e.g.*, an aggressive remediation strategy) that have the potential to reduce costs and provide additional environmental monitoring alternatives compared to those currently in use at McClellan AFB.

McClellan AFB was designated by the Strategic Environmental Research and Development Program (SERDP) as a NETTS location in 1993. The primary focus of the SERDP and NETTS is the evaluation of innovative technologies for the treatment and monitoring of chlorinated hydrocarbons and metals in soil and groundwater. SERDP provided funding to McClellan AFB to establish the infrastructure for the NETTS location, and SERDP continues to provide McClellan AFB with funds to maintain the infrastructure of the NETTS location. The NETTS program identifies test locations with established infrastructures for the pilot-scale to full-scale tests of emerging or innovative technologies that can potentially reduce costs and risks associated with current cleanup processes. The technologies must be applicable to the Installation Restoration Program (IRP) efforts for the Air Force and other Department of Defense (DoD) facilities. The ultimate goal of the NETTS program is to accelerate the availability of these new technologies for use.

1.2 TECHNOLOGY NEED

McClellan AFB has identified the need to evaluate alternative technologies to remediate volatile organic compound (VOC)-contaminated groundwater because of the long estimated length of time to reach cleanup levels, as presented in the *Basewide VOC Feasibility Study (FS) Report* (CH2M HILL, 1999). A location in Operable Unit (OU) B was chosen for evaluating the feasibility of using an aggressive remediation strategy. This area encompasses one of the groundwater volumes that was predicted to take the longest time of any groundwater volume beneath the base to reach maximum contaminant levels (MCLs) in monitoring zone A – between 100 and 500 years. Several alternatives to address VOCs in soil and groundwater were presented in the VOC FS. New extraction wells are proposed in alternatives 2B and 3B for this area. If these alternatives are not used and no new extraction wells are installed, contaminated groundwater would be captured by extraction wells located downgradient of the site, or be degraded to below MCLs in 100 to 500 years (CH2M HILL, 1999).

Implementability and cost of remedial alternatives were two of the criteria examined in the VOC FS, which was prepared to support a record of decision (ROD) and address contamination caused by past hazardous waste disposal practices at McClellan AFB. Because the geology and hydrogeology is similar across the base, results of these demonstrations at this location may be applicable to other contaminated areas at McClellan AFB.

1.3 AMENDMENTS AND MODIFICATIONS

There have been no amendments or modifications to date. This section is reserved for use at a later date.

2.0 SITE DESCRIPTION

This section presents the current understanding of basewide geology, hydrogeology, and contaminant distribution on McClellan AFB and locally at the test area. This information has been obtained from numerous investigative and informational reports completed at the base.

2.1 SITE LOCATION

McClellan AFB is located approximately 7 miles northeast of downtown Sacramento, California. The main base includes 2,949 contiguous acres (Figure 2-1). The base was established in 1936 as the Sacramento Air Depot. As part of its historic and recent mission, the base has provided logistics support for aircraft, weapons systems, communications equipment, and commodity items as well as maintenance, supply, and contracting services. As part of 1995 Basewide Realignment and Closure (BRAC) activities, the decision was made to close McClellan AFB in 2001. Throughout its history, the base has been engaged in a wide variety of operations involving the use, storage, and disposal of hazardous materials. These materials include industrial solvents, caustic cleaners, electroplating chemicals, heavy metals, polychlorinated biphenyls (PCBs), low-level radioactive wastes, and a variety of fuels, oils, and lubricants. Many of these materials have been released into the environment resulting in contamination of surface and subsurface soils, soil gas, and groundwater.

Trichloroethene (TCE) in groundwater beneath the base and nearby off-base properties, first detected in 1979, is one of the most significant environmental concerns at McClellan AFB. To address the environmental contamination at the base, monitoring wells were installed on and off base, and groundwater samples were collected from newly installed and existing monitoring wells under the McClellan AFB IRP. After reviewing the data collected, the U.S. Environmental Protection Agency (U.S. EPA) placed McClellan AFB on the National Priorities List (NPL) in 1987. As a result, McClellan AFB modified the IRP process to meet the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Air Force began a remedial investigation/feasibility study (RI/FS) of the contamination at McClellan AFB (Radian International, 1997).

The area of the test is listed in the Non-VOC FS as a long time to clean up location. The area is shown on Figure 2-2 as a two-dimensional presentation of a volume of groundwater and is located in the southwestern portion of McClellan AFB in northwestern OU B. While a "hot spot" area would be advantageous for the *in situ* oxidation testing, determining the economics of the current location would represent a "worst case" which would only improve at more highly contaminated sites. The area is east and south of Investigative Cluster (IC) 5, west of OU B1, and west of IC 7 (Figure 2-3). This area encompasses one of the groundwater volumes that was predicted to take the longest time of any groundwater volume on base to reach MCLs in monitoring zone A – between 100 and 500 years. Sites near the test area boundaries are listed in Table 2-1. Available remedial investigation (RI) results for this area are presented in the *Interim Basewide Remedial Investigation Report*, Final, Part 2B – *Operable Unit B Remedial Investigation Characterization Summaries* (Radian Corporation, 1995).

Findings from previous investigations conducted within the test area are presented in Table 2-2. The following sites were found to have soil contamination but have not been shown to contribute to groundwater contamination: OU B1; Site 31; Potential Release Location (PRL) 29; Study Area (SA) 12A; and SA 13. The source contributing most to groundwater contamination in this area is probably in OU C1 upgradient of the site (Radian Corporation, 1995). Within OU B and this test area, PRL P-2 (a

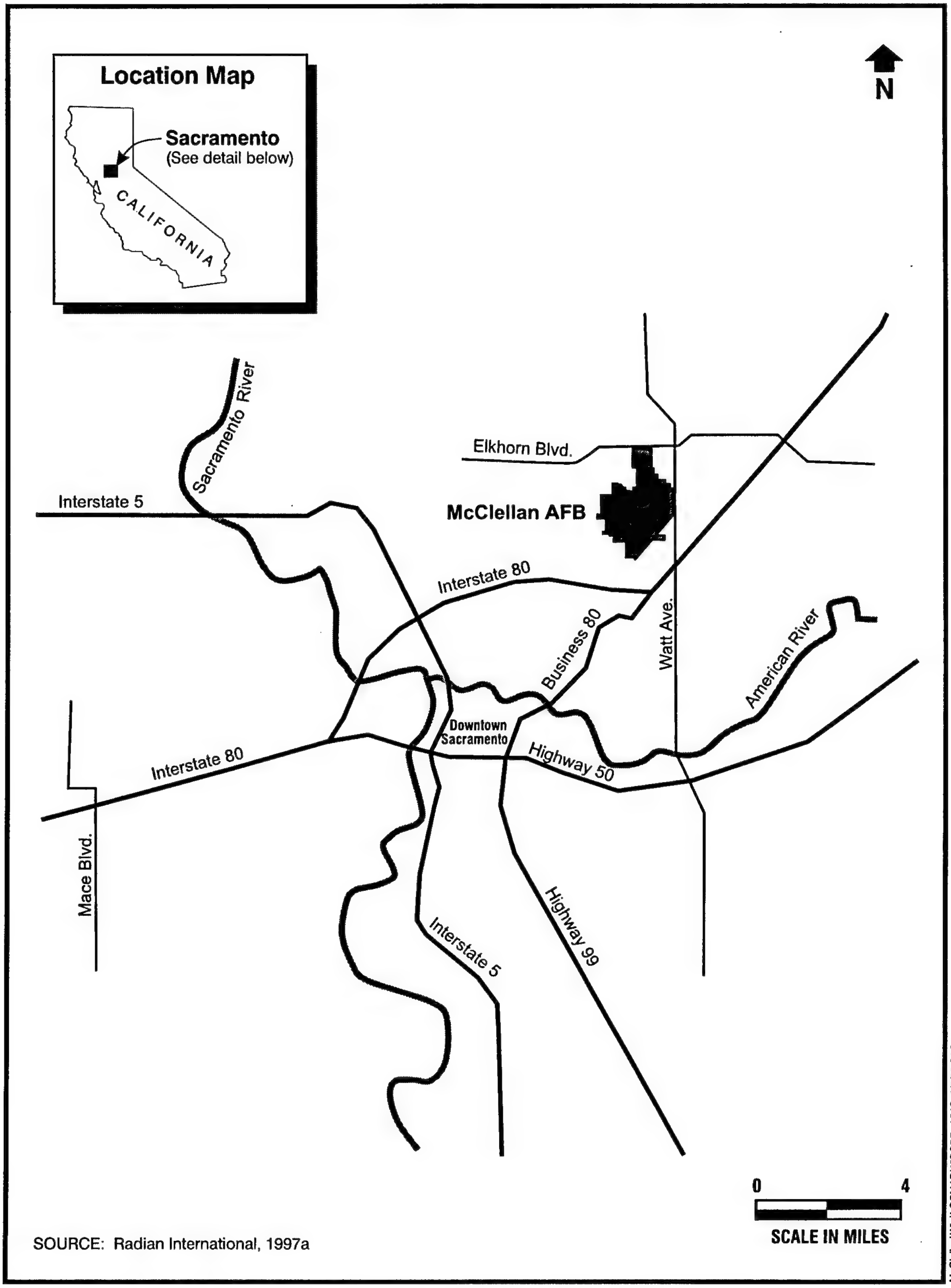

Figure 2-1. Facility Location Map

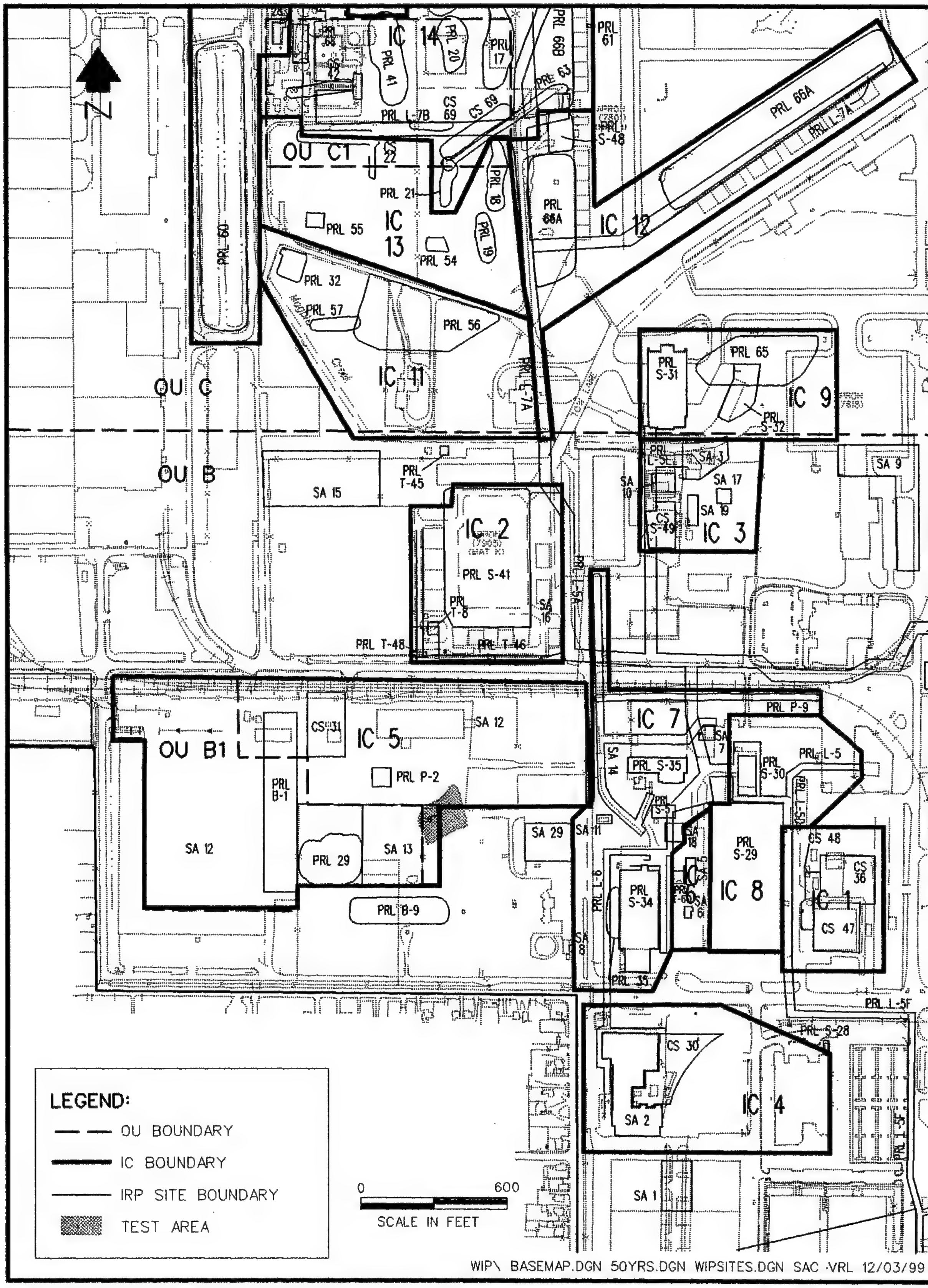

Figure 2-2. Operable Units and Sites near Test Area

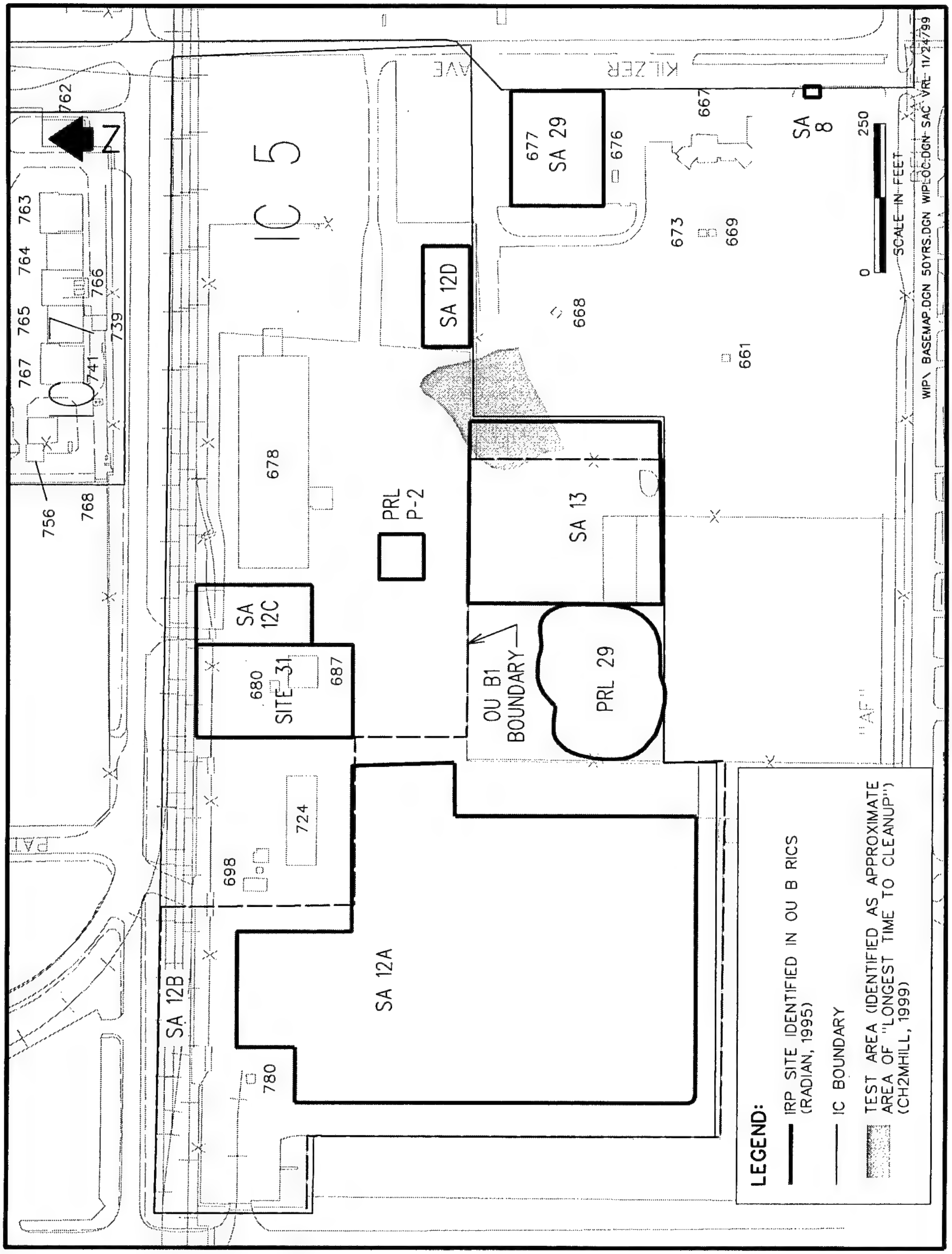

Figure 2-3. Test Area for Aggressive Dewatering and *In Situ* Oxidation Technologies

Table 2-1. Background Information

Associated IC	Time of Operation	Site ID	Function or Building	Materials Handled	Current Status
IC 5	1963–1968	Site 31	Former refuse incinerator (Building 687)	VOCs	Inactive
	1962–1968	PRL P-2	Potential disposal pit	VOCs	Inactive; covered by asphalt and used for storage of spare parts and machinery
		SA 12A (OU B1)	Storage yard	VOCs	Active; paved with asphalt cap; storage of spare parts and machinery
		SA 12C	Reported transformer oil-contaminated area	VOCs	Inactive; paved with asphalt
	1963–1965	SA 12D	Potential disposal pit	VOCs	Active; storage of spare parts and machinery; exposed soil
		PRL 29	Reported burn pit	VOCs, metals	Inactive; unpaved grass field
		SA 13	Civil engineering storage yard	SVOCs, VOCs	Active; paved
	1985–present	Building 724	Building 724; precious metals recovery	Metals	Active
Not associated with an IC		SA 29	Spray booth	VOCs, paints,and oils	Inactive
			Building 677 testing and calibration of equipment	Fuels and oils, mercury, radionuclides, hydraulic fluids	Active
			USTs	Fuels and oils, hydraulic fluids	Active
Not associated with an IC		SA 8	Building 663 UST	Unleaded and leaded gasoline	Installed in 1955. Removed in 1987 and designated as NFA status in 1997.

IC = investigative cluster
ID = identification
NFA = no further action
OU = operable unit
PRL = potential release location
SA = study area
SVOC = semivolatile organic compound
UST = underground storage tank
VOC = volatile organic compound

Table 2-2. Previous Investigations

Site ID	Year, Contractor	Scope of Investigation	Key Findings
PRL 29 (OU B1)	1993, Radian Corporation	Approximately 370 surface soil samples were collected from a grid (10 feet spacing).	PCB, dioxin, and furan concentrations in surface soil were highest in the northern portion of the site.
SA 12A (OU B1)	1993, Radian Corporation	Approximately 1,200 surface soil samples were collected. 22 sediment samples were collected from the three on-site drainages and the combined drainage channel that leads to Magpie Creek.	PCBs were reported at concentrations greater than 500 mg/kg in the northwest portion of the site. SVOCs, TPH, and inorganic species above background were also reported.
SA 13 (OU B1)	1993, Radian Corporation	Approximately 130 surface soil samples were collected from a grid (25 feet spacing).	One sample (in the north central part of the site) had a PCB concentration exceeding 10 mg/kg, eight samples had PCB reported at less than 10 mg/kg, and the remainder had no PCB detected.
IC 5	1986, McLaren Environmental Engineering, Inc.	Area B investigation, site characterization.	Identified Site 31 as a potential source of contamination.
	1991, Radian Corporation	Soil gas investigation. Five borings were sampled.	HVOC concentrations greater than 10,000 ppbv detected in the southern portion of Site 31.
	1991, Radian Corporation	OU B preliminary assessment.	Compiled historical information about operations and investigations at sites in IC 5.
	1995, Radian Corporation	OU B RI.	Inorganic species (lead, vanadium, barium) were reported greater than background in isolated samples. Lead was reported above residential preliminary remediation goals in the surface scrape collected at IC05S2222.
	1995, Radian Corporation	OU B, IC 5 RI (excluding OU B1) – 916 soil samples, 122 soil gas samples, and three HydroPunch® groundwater samples collected.	One source area – PRL P-2 – was identified as a source of soil gas contamination. The soil gas contamination is contributing to additional groundwater contamination coming from upgradient sources in OU C1 as indicated by 1,1-DCE at 59.7μg/L (greater than 25 times the concentration reported in the upgradient well MW-164), TCE at 12.8 μg/L, and *cis*-1,2-DCE at 10.6 μg/L reported in the PRL P-2 groundwater samples. SA 12A is contaminated with VOC in soil gas, SA 12D is contaminated with Freon® 113 in soil gas and inorganic species in soil. Building 724 is contaminated with PCB and inorganic species soil contamination.

Table 2-2. (Continued)

DCE	=	dichloroethene	RI	=	remedial investigation
HVOC	=	halogenated volatile organic compound	SA	=	Study Area
IC	=	Investigative Cluster	SVOC	=	semivolatile organic compound
mg/kg	=	milligrams per kilogram	TCE	=	trichloroethene
OU	=	operable unit	TPH	=	total petroleum hydrocarbons
PCB	=	polychlorinated biphenyl	VOC	=	volatile organic compound
ppbv	=	parts per billion by volume	µg/L	=	micrograms per liter
PRL	=	Potential Release Location			

reported waste pit) has been identified as a source of VOC soil gas contamination and is causing groundwater contamination. A soil vapor extraction (SVE) system was installed at this area in 1999 and is scheduled to begin operation in 2000. Soil gas and groundwater contamination has also been identified beneath IC 7 located to the west and crossgradient of the test area. The IC 7 SVE system is located approximately 700 feet east of the test area and is operational.

2.2 GEOLOGY

2.2.1 Regional Geology

McClellan AFB is centrally located within the Great Valley, a wedge-shaped accumulation of sediments, bounded on the west by the Coast Range and on the east by the Sierra Nevada mountains. The wedge of sediments that comprises the Great Valley was accumulated in a downward "trough" between late Mesozoic to late Cenozoic time (from approximately 144 million to 10,000 years ago). This trough is asymmetrical because of uplifting of the Sierra Nevada along the eastern edge. The greatest thickness of sediments is in the western portion of the Great Valley (estimated to be 20,000 feet thick) and generally slopes up to the east to the Sierra Nevada foothills (Norris, 1990).

From the ground surface to a depth of 450 feet below ground surface (bgs), the subsurface of McClellan AFB consists of alluvial and fluvial sediments eroded from the Sierra Nevada and deposited over the last 5 million years. Soils found in the vadose zone are composed of interbedded layers of sands, silts, and clays. The thickness of most layers varies from a few inches to 5 feet, particularly in the upper 40 feet of the vadose zone. In some parts of McClellan AFB, layers of one lithology may be 6 to 35 feet thick at depths greater than 40 feet bgs. A discontinuous layer of silica-cemented hardpan, approximately 2 to 4 inches thick, has developed over large areas of the base at 3 to 10 feet bgs. This hardpan may impede, but does not halt, the downward percolation of surface water that infiltrates the surface soil.

Water and soil gas behavior in the vadose zone is largely determined by the properties of the sediment layers. As a result of the heterogeneity of the vadose zone beneath McClellan AFB, permeabilities may increase or decrease by factors of 1,000 to 10,000 (3 to 4 orders of magnitude) where different lithologies (sand and silt or sand and clay) are in contact. In addition, the poorly sorted condition of most of the layers, grain cementation, and the presence of plant root bores affect the permeability and porosity. The bottom of the vadose zone is determined by the location of the capillary fringe, in which all of the pores between soil particles are filled with water held by capillary forces just above the water table (Radian International, 1999a).

For a more detailed description of regional geology, refer to the *Groundwater RI/FS Study Report* (CH2M HILL, 1994).

2.2.2 Site Geology

Groundwater contamination at the test area originates from upgradient sources probably from OU C1. A source of contamination, such as IC 7, that is now crossgradient may have contributed in the past to groundwater contamination at the test area. The test area is located in the southwestern portion of McClellan AFB in OU B. Portions of the area are paved; however, the test area is mostly unpaved with exposed soils and grass-covered ground. Fill material extends from ground surface to approximately 1 foot bgs in the test area and to 7 feet bgs in some areas. Below ground surface (pavement and/or fill) lie interbedded silts, sands, and clays.

Geologic cross section A-A' (Figure 2-4) trends northwest-southeast in the approximate direction of groundwater flow. Geologic cross section B-B' (Figure 2-5) trends east-west, approximately perpendicular to groundwater flow. Lithologic data from monitoring well (MW)-451 drilled 100 feet south of the test area and in the center of both cross sections indicates that the soils are composed of interbedded sands, silty sands, sandy silts and silts (Appendix A). A silt layer located at about 157 feet bgs in MW-451 marks the top of the B zone and extends to 200 feet bgs. Soil layers across the base are laterally discontinuous, allowing vertical migration of groundwater between the A and B zones. MW-451 is just south of the test area and data from one soil boring does not provide sufficient data to describe site-specific geology and hydrology. Therefore, the absence of lithology and soil characteristics detail across the site is a data gap. Additional soil borings are needed to provide these data.

2.3 HYDROGEOLOGY

2.3.1 Regional Hydrogeology

The geologic environment beneath the base is a complex series of alluvial deposits that were laid down, eroded, and re-deposited by actions of streams, rivers, and floods. The alternating layers of unconsolidated sand, silt, clay, and gravel form a single groundwater system. The geologic and hydrologic properties of the aquifer formation vary over short distances, but the aquifer is laterally and vertically interconnected by permeable sand and gravel lenses.

Groundwater recharge in the eastern portion of the Sacramento Valley occurs as a result of leakage from streams and rivers, percolation of precipitation and irrigation water through soils, and migration of runoff along fracture zones and formation contacts in the foothills of the Sierra Nevada. The upper waterbearing zone in the Sacramento Valley is recharged predominantly through percolation of water from the ground surface. This process is generally inhibited by the presence of hardpan throughout much of the valley. Therefore, groundwater recharge to the upper zone occurs predominantly through past and present stream channels consisting of permeable sands and gravel that allow percolation of surface waters into the saturated zone. According to the CDWR (1974), the permeable buried stream channels interlayered with less permeable sediments have resulted in a network of tabular, shallow aquifers throughout the county. Hardpan locally restricts downward migration of water to the deeper aquifers.

Groundwater discharge in the Sacramento Valley occurs predominantly through pumping. Since the turn of the century, the extraction of groundwater for irrigation, industrial, municipal, and domestic use has

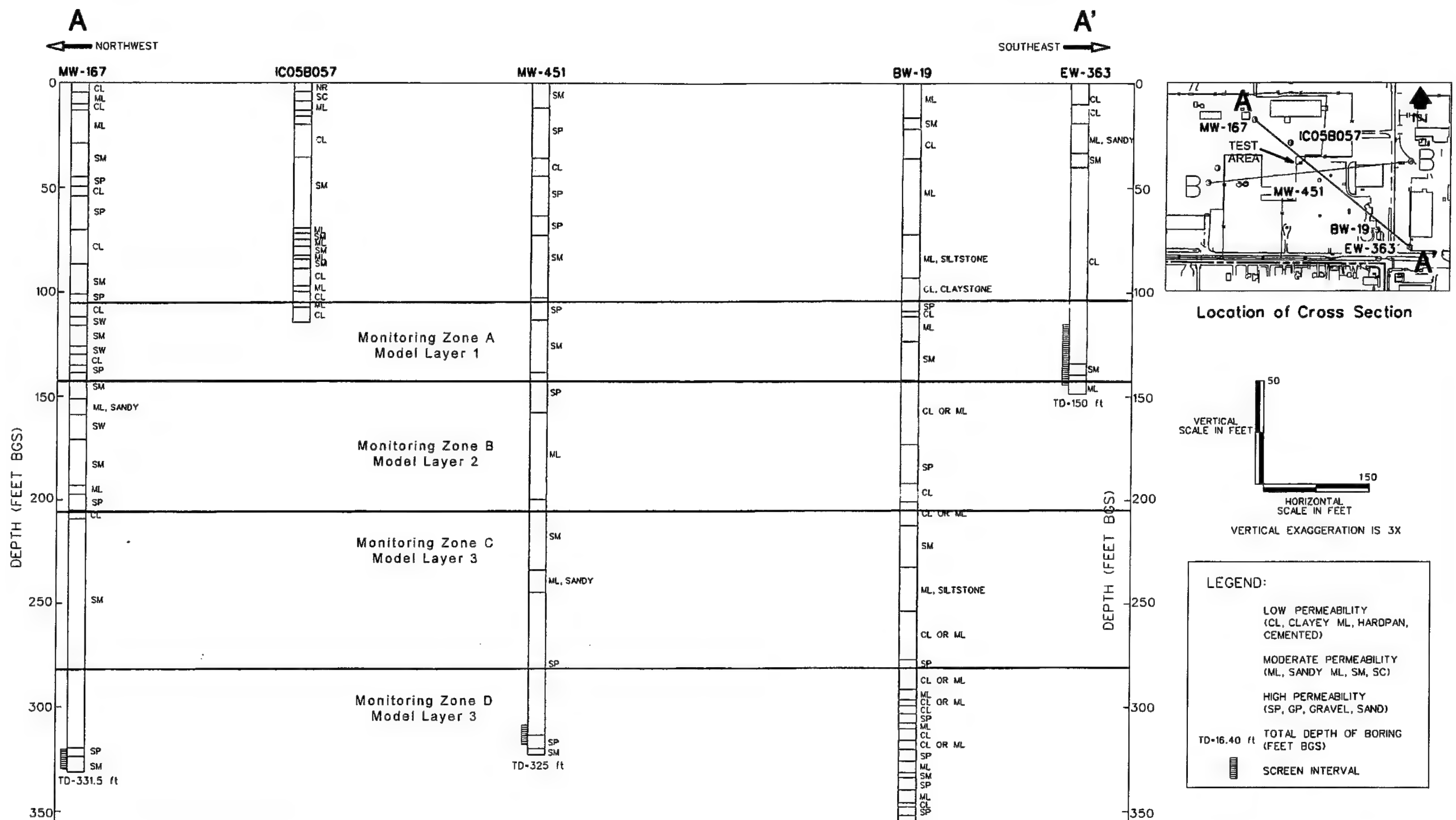

Figure 2-4
Geologic Cross Section A-A' and Preliminary Model Layers

MCCLELLAN\ WIP\ XSECLOC.DGN WIP_A-A1.DGN SAC VRL 3/16/00

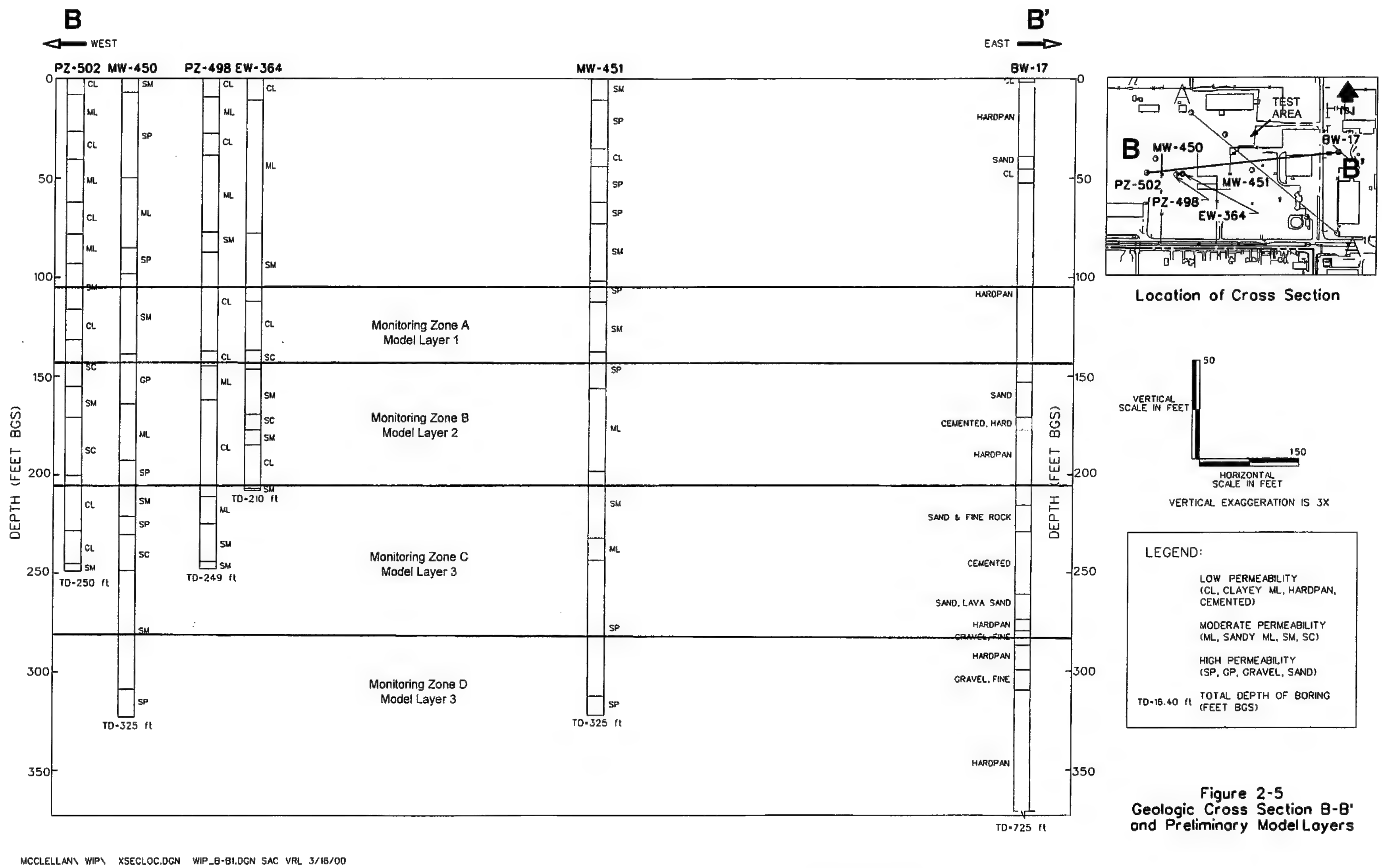

Figure 2-5
Geologic Cross Section B-B' and Preliminary Model Layers

substantially altered the groundwater levels and gradients. Presently, the regional groundwater flow in the vicinity of McClellan AFB is southerly toward a pumping depression south of the base.

The water table in the vicinity of the base fluctuates seasonally about 5 feet per year. Variations in the depth to water depend predominantly on local topography and locations of groundwater depressions caused by high capacity extraction wells. The annual mean water level is declining as a result of groundwater extraction for private, public, industrial, and domestic purposes. The water table declined by 0.9 to 1.7 feet each year between 1955 and 1985. Within the last 10 years, water levels in the A monitoring zone have been declining at a rate of 1 to 2 feet per year (Radian International, 1999b). Groundwater levels are expected to continue declining in future years because of overdrafting of groundwater aquifers. However, water levels near the test area have been increasing since approximately 1997. Data from monitoring wells near the test area indicate an approximate 2 to 3 feet increase in water elevation from approximately 1997 to the third quarter of 1999 (Radian International, 1999d). This is probably due to the shutdown of Base Well 18.

Groundwater beneath McClellan AFB is encountered at approximately 100 to 115 feet bgs. Groundwater flows generally to the south-southwest through the the A monitoring zone. The hydraulic conductivity across the base of the A monitoring zone has been calculated to range from 0.8 to 160 feet/day. The hydraulic conductivity of the B monitoring zone ranges from 1.8 to 50 feet/day (CH2M HILL, 1999).

Groundwater flow beneath McClellan AFB is also controlled by the pumping of numerous production and extraction wells located on base. The McClellan AFB groundwater monitoring report fourth quarter 1998 (4Q98) gives specific information on the number, identification, and history of base and extraction wells (Radian International, 1999b).

Groundwater pumping for base, municipal, and private uses near McClellan AFB has also altered the regional groundwater flow direction. In 1955, groundwater flow was generally to the southwest toward a pumping depression southwest of the base. By 1965, this depression had deepened, and a second pumping depression developed directly south of the base as a result of the operation of production wells located near the base boundary. Flow directions were therefore altered as groundwater on the base began to flow to the south and groundwater west of the base began to flow in an east-southeast direction in the late 1950s or early 1960s (Radian Corporation, 1986).

The aquifer system at McClellan AFB has been divided into a series of monitoring zones for investigative purposes. The monitoring zones are layers that together act as preferential pathways for horizontal groundwater flow within the aquifer system. The monitoring zones are not hydraulically independent and groundwater does flow vertically between zones. Previous investigations have also defined monitoring zones. The Preliminary Groundwater Operable Unit Remedial Investigation (PGOURI) refined those zones to better define the potential for contaminants to migrate horizontally or vertically. The monitoring zones are designated A through F, from shallowest to deepest. Generally, the zones thicken and dip across the base from east to west, following the geologic sequence. Figure 2-6 shows a generalized cross section of these hydrogeologic monitoring zones. However, it is entirely possible for two adjacent wells screened at different depths to be screened within the same zone, or for two wells screened at similar depths to be screened in different zones. These local variations in zone depths are due to the heterogeneity of the deposits beneath McClellan AFB and to the relative abilities of different deposits to conduct water. At some locations, isolated or intermediate semi-confined zones were identified between the monitoring zones.

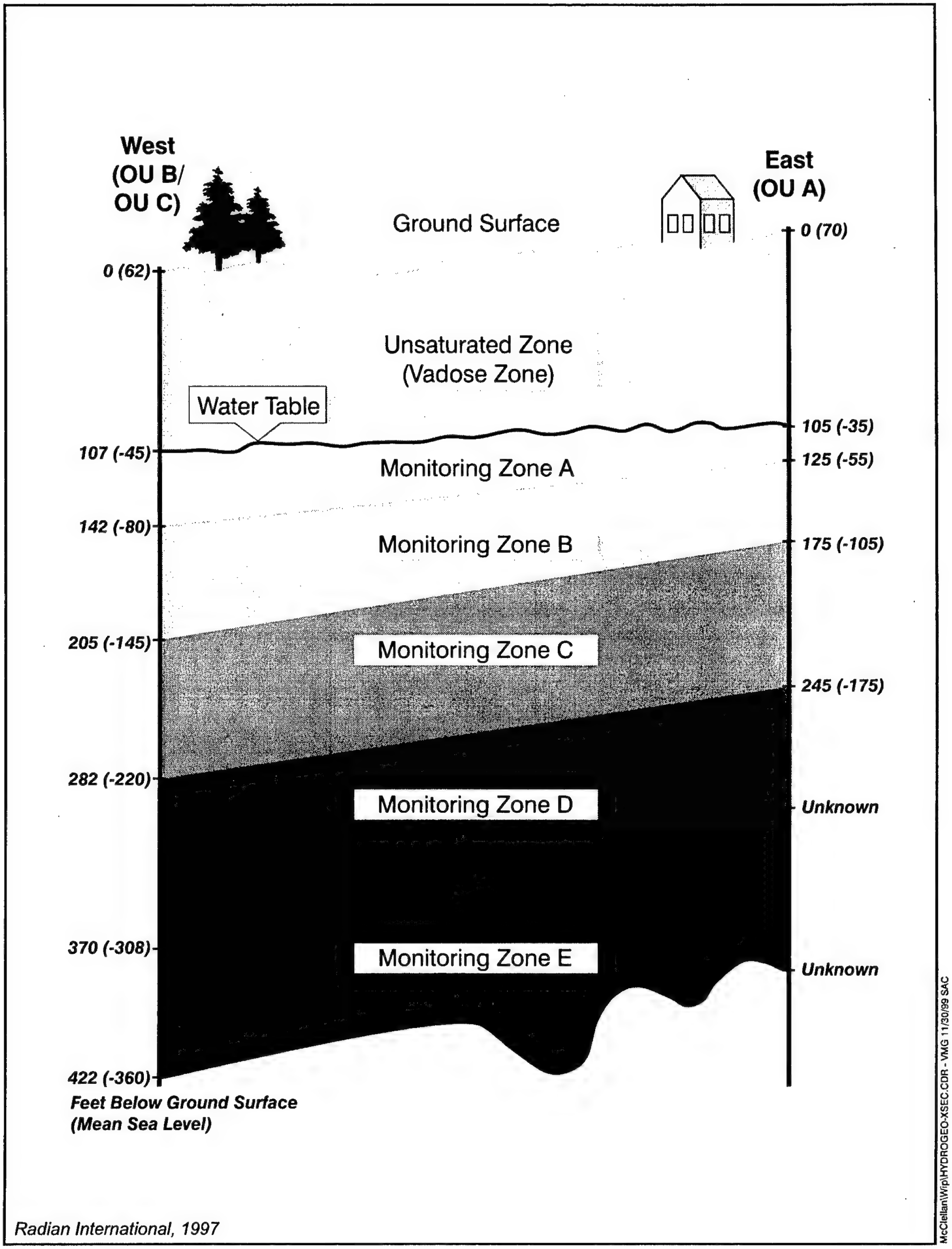

Figure 2-6. Generalized Hydrogeologic Cross Section of McClellan AFB

2.3.2 Site Hydrogeology

Base Well (BW) 18, located southeast of the test area (Figure 2-7), was a water supply well to which wellhead treatment was added when TCE contamination was detected. BW-18 was one of the major groundwater extraction systems on base. However, because the well had pumped most of its water from the B, C, and D monitoring zones, pumping the well drew the contamination downward into lower waterbearing units. Therefore, the well was shut down in September of 1998 and is scheduled to be decommissioned. When operating, BW-18 had a strong hydraulic effect on the groundwater in this portion of the base. A groundwater depression with a radius of approximately 600 feet surrounded BW-18 in both the A and B monitoring zones.

Several extraction wells and related piezometers have been installed in the southwest portion of the base to capture and treat contaminated groundwater. Extraction well (EW)-361, screened in the AB monitoring zone, is located approximately 1200 feet southeast of the test area. EW-364, screened in the BC monitoring zone, is located 400 feet west of the test area. These wells have greater influence on the test area than two other extraction wells installed near BW-18: EW-363, screened in the A monitoring zone, and EW-378, screened in the C monitoring zone, are located approximately 1,400 feet east-southeast and 1,100 feet southeast of the test area, respectively.

Since the operation of the extraction wells began, statistical analyses show that concentrations of TCE and tetrachloroethene (PCE) have increased in some A zone wells near the test area (MW-164 and MW-217), and concentrations of TCE, PCE, and *cis*-1,2-dichloroethene (DCE) have decreased in the other A zone wells (MW-155, EW-303, and EW-304). Concentrations of TCE and *cis*-1,2-DCE have decreased in all B zone wells (MW-156 and MW-165) and C zone wells (MW-132, MW-166, and MW-219) (Radian International, 1998a). Table 2-3 presents a list of extraction wells near the test area with their average operating flow rates.

Table 2-3. Flow Rates of Extractions Wells Near Test Area

Well Number	Monitoring Zone	GWOU Phase[a]	Average Operating Flow Rate (gpm)[b]			Capacity With Existing Pump and Total Flow
			Jul-99	Aug-99	Sep-99	
EW-63	B	--	13.7	17	17	20
EW-246	AB	--	10.9	8.2	8.5	10
EW-247	C	--	146.5	154	155	225
EW-303	A	1	6.3	5.4	5.3	11
EW-304	A	1	10	7.4	10.2	11
EW-308	C	1	105.2	102.9	102	150
EW-309	D	1	81	80	80	180
EW-310	B	1	34.2	32	33.3	60
EW-363	A	2	10.9	11.1	9.6	NA
EW-364	BC	2	0	75	72.1	NA
EW-378	C	2	40	40	41.3	NA

[a] Well in operation prior to GWOU Phase 1 are indicated by a "--"
[b] Source: Fax transmission from the IT Group.

gpm = gallons per minute
GWOU = Groundwater Operable Unit
NA = not available

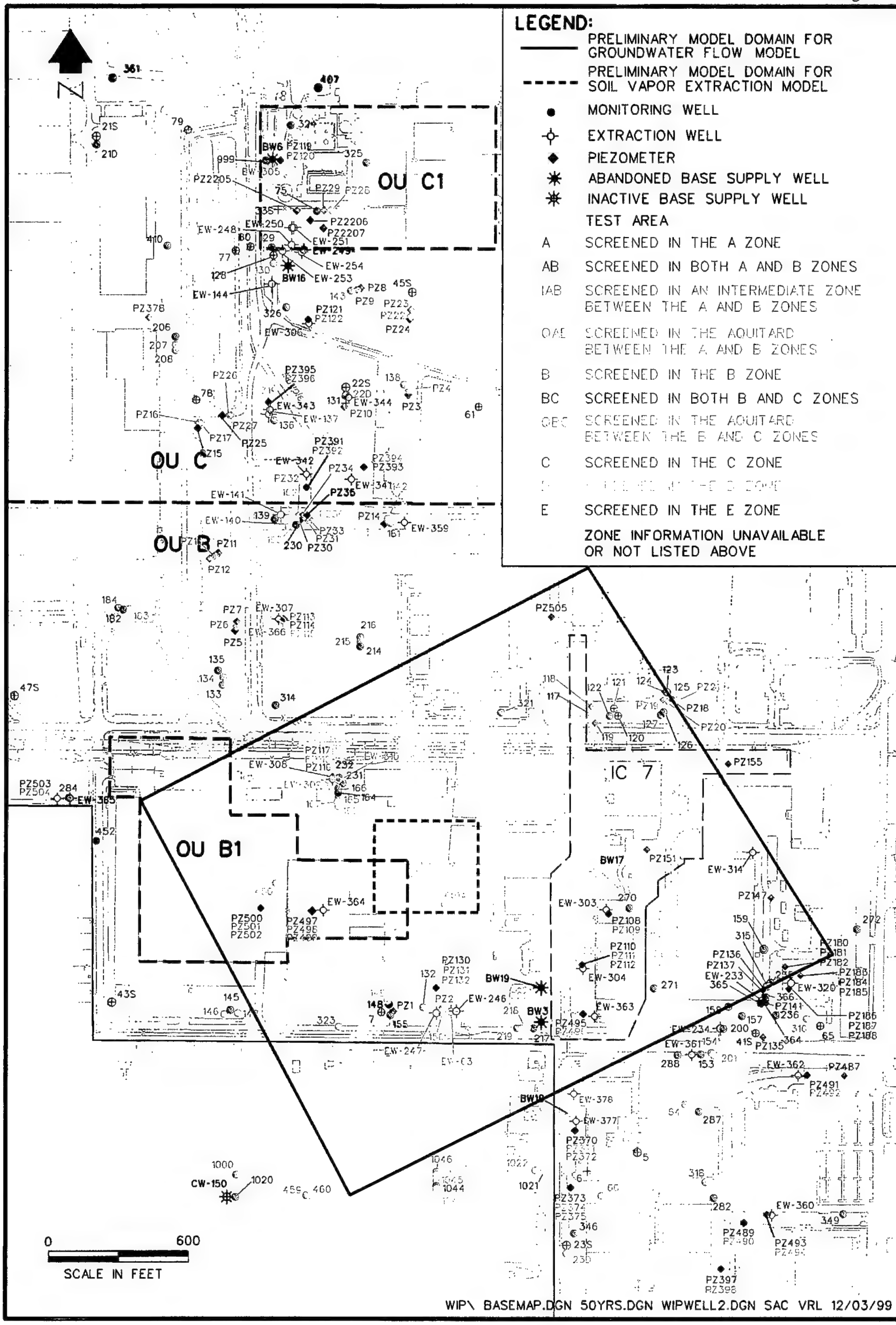

Figure 2-7. Preliminary Model Domain for Groundwater Flow Model and Soil Vapor Model

Groundwater beneath the test area is encountered at approximately 105 feet bgs. Using first quarter 1999 (1Q99) water elevation measurements, groundwater in OUs B and C flows south towards the extraction wells located to the southeast of the test area. (1Q99 data were used because extraction wells were turned off during 2Q99.) Groundwater elevations generally increase in the winter and decrease during summer months (Radian International, 1999a). Locally, groundwater flows toward the extraction well system of EW-246, EW-247, and EW-63 located south of the test area. The extraction wells EW-308, EW-309, and EW-310 are located northwest of the test area and draw groundwater toward them. This may create a stagnation zone in the test area. Movement of the contaminated groundwater from the stagnation zone is limited; therefore, VOC migration that is retarded compared to groundwater is very slow. The slow movement results in the lengthy cleanup time of 100 to 500 years.

The horizontal gradient was 0.0009 ft/ft across the area in 1Q99 between MW-164 and MW-217. Vertical gradients were calculated from 10 pairs of wells surrounding the test area. Table 2-4 presents the vertical gradients calculated for the site. Gradients were calculated using 1Q99 water levels. However, gradients may change from the effects of extraction wells installed during the Groundwater Operable Unit (GWOU) Phase 2 effort (CH2M HILL, 1997), which began operating during the summer of 1999.

Water levels measured in four pairs of wells in the A and B monitoring zones indicate that the vertical gradient between these monitoring zones varies – two pairs of wells had an upward vertical gradient and three pairs had a downward vertical gradient. Two of the three well pairs in the B and C monitoring zones had an upward vertical gradient. Both of the two pairs of wells in the C and D monitoring zones had an upward gradient. These data indicate that the A zone may be recharged by the B zone during dewatering attempts.

The following hydrogeologic data gaps were identified for the test area:

- Soil characteristics and lithology of the A, B, and C monitoring zones across the site.
- Continuity of a horizontal boundary between the A and the B monitoring zones and between the B and the C monitoring zones. The silt layer between the A and B monitoring zones may not be laterally continuous or sufficient for dewatering.
- Degree of hydraulic connectiveness between the A, B, and C monitoring zones.
- Hydraulic characteristics of the A, B, and C monitoring zones.

2.4 CONTAMINANT DISTRIBUTION

The subsurface beneath McClellan AFB is divided into the vadose zone (unsaturated) and five groundwater monitoring zones (saturated) mentioned in Section 2.3.2 on the basis of hydrogeologic characteristics. These monitoring zones are used to monitor the horizontal and vertical migration of contaminants in groundwater and local variations in horizontal and vertical gradients.

PRL P-2, located to the northwest of the test area, has been identified as a source area for soil gas contamination that is contributing to groundwater contamination (Figure 2-3). A maximum concentration of 1,1-DCE (230,000 parts per billion by volume [ppbv]) was reported at 78 feet bgs. The highest

Table 2-4. 1Q99 Vertical Gradients for Test Area

Well ID	1Q99 Water Level Measurement (feet msl)	Monitoring Zone	Top of Screen (feet bgs)	Bottom of Screen (feet bgs)	1Q99 Vertical Gradient
MW-217	-47.1	A	127	137	0.0663 upward
MW-218	-43.85	B	176	186	
MW-218	-43.85	B	176	186	0.0185 upward
MW-219	-42.86	C	229.5	239.5	
MW-219	-42.86	C	229.5	239.5	0.0426 upward
MW-322	-39.43	D	310	320	
PZ-108	-46.91	A	123	128	0.2580 upward
PZ-109	-41.75	B	143	148	
PZ-110	-47.05	A	125	130	-0.0470 downward
PZ-111	-47.99	B	145	150	
PZ-111	-47.99	B	145	150	0.0530 upward
PZ-112	-43.75	C	225	230	
PZ-116	-48.26	B	190.25	195.25	-0.0134 downward
PZ-117	-49.06	C	250	255.33	
PZ-117	-49.06	C	250	255.33	0.0732 upward
PZ-118	-43.58	D	325	330	
PZ-130	-45.07	A	112	117	-0.0344 downward
PZ-131	-46.05	B	140.5	145.5	
PZ-130	-45.07	A	112	117	-0.0267 downward
PZ-132	-47.02	B	185	190	

bgs = below ground surface
msl = mean sea level
1Q99 = first quarter 1999

concentration of TCE (69,000 ppbv) was reported at 38 feet bgs. TCE and 1,1-DCE concentrations are generally greater than 1,000 ppbv throughout the vadose zone.

Equilibrium calculations for soil gas sample data collected from PRL P-2 at 105 feet bgs indicate that in water leachate from the vadose zone the concentrations of both TCE and 1,1-DCE would exceed their MCLs.

SA 29, on the eastern side of the test area, contains VOC soil gas contamination that migrated from sources in IC 7 (located to the east) and in IC 5 at SA 12D. At IC 7, maximum concentrations of 2,500

ppbv Freon® 113 and 6,000 ppbv TCE were detected at 21 feet bgs, and at IC 5, a maximum concentration of 3,400 ppbv Freon® 113 was detected at 21 feet bgs.

Lower concentrations of Freon® 113 (37 ppbv), PCE (30 ppbv), and TCE (110 ppbv) detected at SA 8 (located to the southeast of the test area) also originate from the east at IC 7. The concentrations of toluene (13 ppbv) and m,p-xylene (20 ppbv) reported in soil gas at 21 feet bgs at SA 8 may be the result of leaks from the former underground storage tank (UST) or associated piping.

Data presented in the engineering evaluation and cost analysis for IC 5 (URS, 1999) was collected west of the test area in IC 5. The contaminants reported in the samples were similar to those measured during the RI. However, the results were generally lower than data presented in the RI, which may indicate that the soil gas plume has been attenuated or migrated. The dominant VOCs reported at IC 5 were TCE and 1,1-DCE, which comprise greater than 95% of the VOC mass (URS, 1999). These data confirm results from the RI conducted at PRL P-2. Because TCE and 1,1-DCE have been reported in groundwater beneath the site, soil gas contamination from PRL P-2 has migrated to groundwater.

The following contaminants have been reported in wells within the test area at concentrations exceeding MCLs:

- TCE
- PCE
- *cis*-1,2-DCE
- 1,1-dichloroethene (1,1-DCE)
- 1,2-dichloroethane (1,2-DCA)

1,1-DCA and chloroform have also been reported; however, concentrations are less than MCLs.

The contaminants (TCE, PCE, *cis*-1,2-DCE, 1,1-DCE, and 1,2-DCA) are within the larger "OU B/OU C groundwater plume" that extends from the north in central OU C downgradient and south through OU B and off base. TCE is an ubiquitous contaminant in this area as it is for the entire base. In monitoring zone A, the reported concentrations of TCE range from 15 micrograms per liter (µg/L) detected in MW-155 to 159 µg/L detected in MW-217 (Figure 2-8). The range of TCE concentrations was 2.07 µg/L (from MW-218) to 99.2 µg/L (from MW-156) in monitoring zone B (Figure 2-9) and 0.293 µg/L (from MW-219) to 26.8 µg/L (from MW-166) in monitoring zone C (Figure 2-10). TCE was also detected in monitoring zones D and E; however, concentrations are less than MCLs (Radian International, 1999a). For maps depicting concentration isopleths for VOCs other than TCE, refer to the latest Groundwater Monitoring Program (GWMP) Quarterly Report.

All other contaminants are located within the TCE plumes identified on Figures 2-8 through 2-10. PCE was reported in monitoring zone A in concentrations ranging from less than detection to 11.4 µg/L, which exceeds the MCL of 6 µg/L. PCE was not detected in monitoring zones B, C, or D in the last sampling events (Radian International, 1999a).

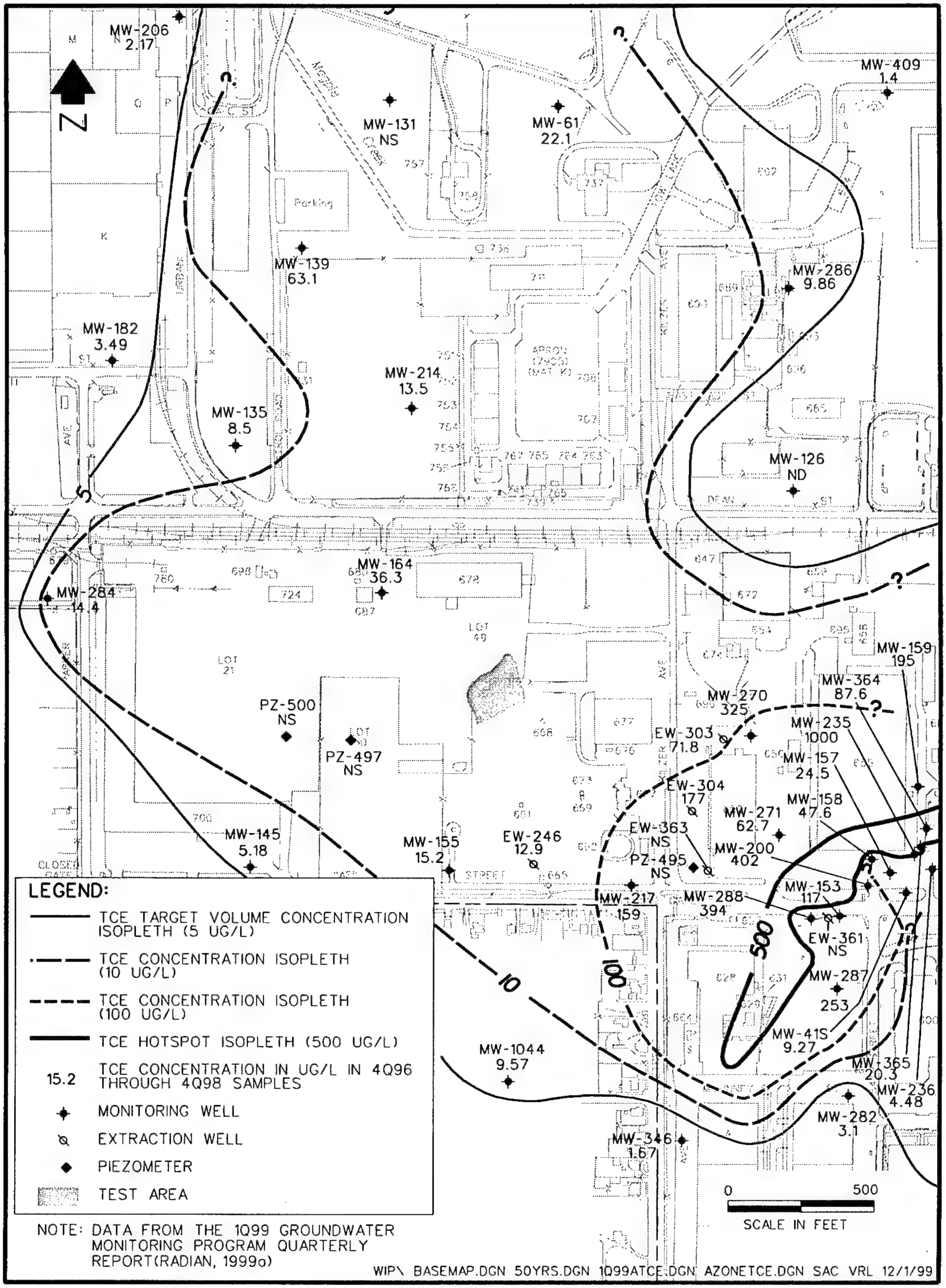

Figure 2-8. TCE Groundwater Contamination in the A Monitoring Zone at the Test Area, McClellan AFB

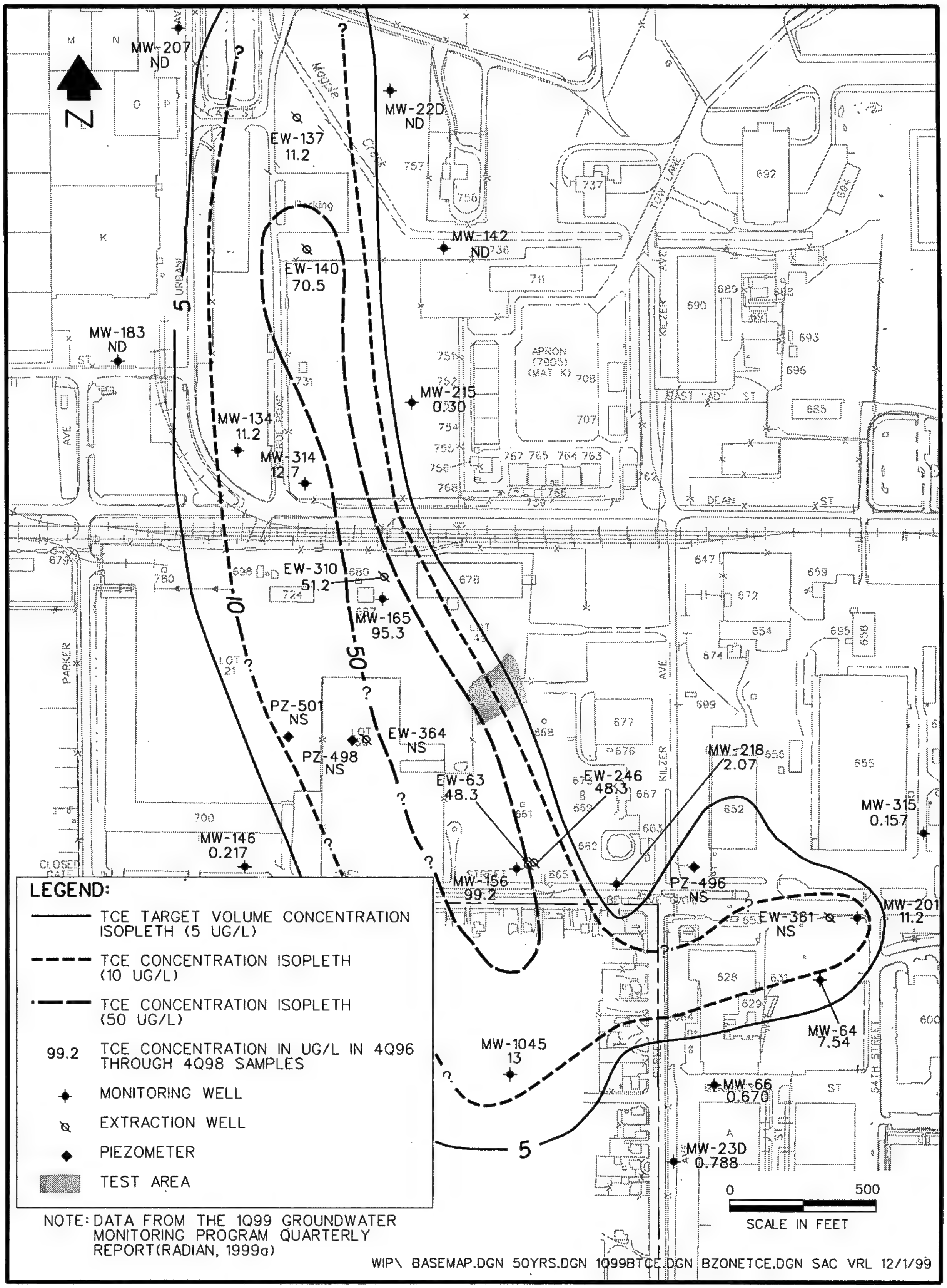

Figure 2-9. TCE Groundwater Contamination in the B Monitoring Zone at the Test Area, McClellan AFB

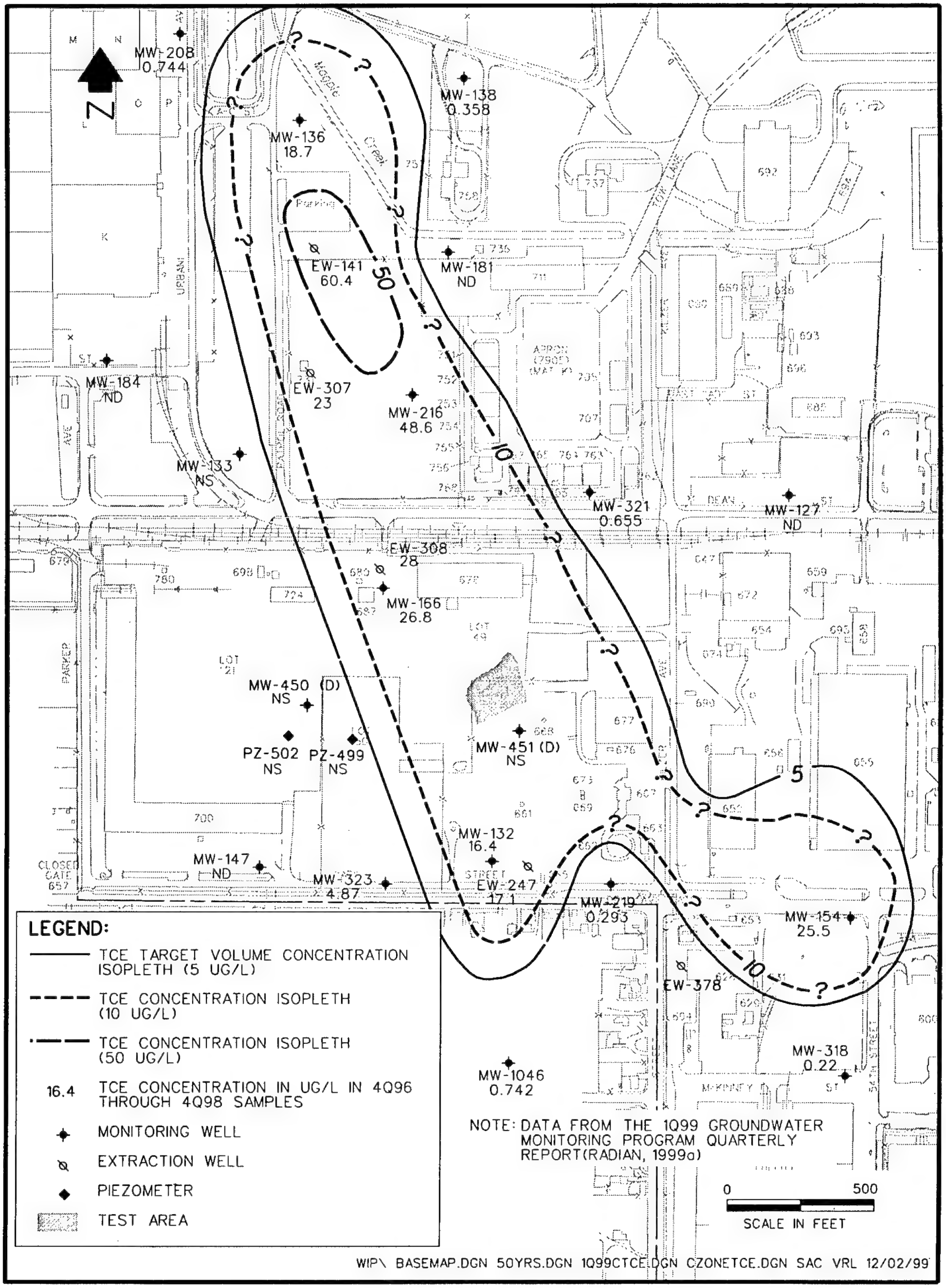

Figure 2-10. TCE Groundwater Contamination in the C Monitoring Zone at the Test Area , McClellan AFB

Concentrations of *cis*-1,2-DCE exceed its MCL of 6 µg/L in monitoring zone A (ranging from 7.83 µg/L to 22.5 µg/L), in monitoring zone B (ranging from 1.47 µg/L to 23 µg/L), and in monitoring zone C (ranging from less than detection to 10.7 µg/L). A concentration of *cis*-1,2-DCE was reported in monitoring zone D; however, concentrations were less than MCLs (Radian International, 1999a).

1,1-DCE has been reported; however, concentrations have not exceeded its MCL of 6 µg/L in groundwater sampled through 1Q99 (Radian International, 1999a).

1,2-DCA exceeds its MCL of 0.5 µg/L in monitoring zone B. Concentrations have been reported from less than detection to 0.786 µg/L (Radian International, 1999a).

Most of groundwater contamination beneath the test area originated in OU C1. However, the contaminant 1,1-DCE probably originated from PRL P-2, which may also be contributing other contaminants to groundwater (Radian Corporation, 1995).

The contaminant distribution and concentration in the A and B monitoring zones have been identified as data gaps within the test area. Additional borings will be drilled and wells will be installed and sampled to obtain data needed to fill these data gaps.

2.5 SITE CONCEPTUAL MODEL

The site conceptual model in this study will be the framework of information for the modeling to simulate the aggressive dewatering strategy. This strategy, which uses aggressive dewatering and SVE, is relatively unknown. In order to satisfy the goal of this project, to substantially reduce the VOC contamination in groundwater, models will be used to simulate the technologies in order to compare the costs of the aggressive dewatering strategy compared to conventional pump and treat technology.

During development of the site conceptual model, data gaps were identified; however, additional data may need to be collected. The conceptual model will be used to develop a groundwater model and soil vapor model.

Two models are proposed for this study: a groundwater flow and transport model and a soil vapor model. The groundwater model will simulate the dewatering of the A monitoring zone. When the lowering of the water table reaches a steady-state condition, an SVE model will be used to simulate vapor extraction from the dewatered zone. The SVE model and dewatering procedure will be turned off and the area will be allowed to resaturate. The groundwater model will then be employed to determine the fate and transport of contaminants remaining in the resatured volume. Based on its versatility and availability, the three-dimensional model FEMWATER (Lin et al., 1997) was chosen as the groundwater model. FEMWATER is a three-dimensional finite-element model that is capable of simulating flow and dissolved phase migration in variably saturated media. This model will be used to predict lowering of the water table and migration of contaminants toward dewatering wells. A second model will be required to evaluate SVE remediation in the vadose zone above the lowered water table. Transfer of results/data between FEMWATER and the SVE model will be critical. Based its availability and its ability to handle multiple wells, VENT 2D (Benson, 1991) was chosen as the SVE model.

All VOCs above MCLs will be included within the model. Historically, the concentration of TCE is higher than the concentration of other contaminants surrounding the test area.

2.5.1 Site Conceptual Parameters for the Numerical Groundwater Model – FEMWATER

A conceptual model is a representation of the groundwater flow system that is used to determine the dimensions of the numerical model and the design of the model grid. The conceptual model is used to simplify complex field relationships and organize the associated field data so that the system can be analyzed more readily. Part of the conceptual model includes defining the hydrostratigraphic units, preparing a water budget, and defining the flow system (Anderson and Woessner, 1992).

The purpose of the conceptual model is to develop an understanding of how groundwater flow and contaminant transport take place in the vadose zone and saturated zones. Both flow and transport processes are governed by physiochemical properties of the vadose and waterbearing zones. The key physical properties include: variations in hydraulic conductivity (from place to place and in the vertical and horizontal directions); hydraulic communication between the waterbearing zones; existing gradients caused by local groundwater extraction; and effective porosity in the zones to be dewatered. Results of aquifer tests will be used to develop an understanding of flow within the monitoring zones and across the zones.

Important chemical properties include the type and distribution of contaminants in the vadose zone and aquifer zones and the total organic carbon (TOC) in the vadose zone and aquifer zones. Migration mechanisms affecting contamination at the site will be evaluated.

Cross sections A-A' and B-B' (Figures 2-4 and 2-5, respectively) are the geologic cross sections through the test area. The conceptual model will be specified with three saturated zone layers preliminarily set at the boundaries of the A, B and C monitoring zones ane will designated as model layers 1, 2, and 3, respectively (model layer 3 includes the C and D zones). As discussed in Section 2.0, the hydrostratigraphic units at McClellan AFB are assigned by depth or elevation and are not always separated by low permeability units or aquitards.

The water budget will be estimated based on data presented in the *Remedial Investigation General Framework Report* (Radian International, 1997) and data collected as part of this study (*e.g.*, the aquifer test data). Other peer-reviewed literature may also be consulted in developing the water budget for the study area. The dynamics of the groundwater flow system and the amount of connection between the aquifer zones are crucial factors in determining if the aggressive dewatering strategy can be successful in the test area or other areas at McClellan AFB. Data gaps that will be filled in for this study include: the degree and causes of connection between the A, B, and C monitoring zones, and the hydraulic conductivity and specific yield of the aquifer zones.

The initial model extent is presented on Figure 2-7 and is aligned with the long axis of the model in the direction of regional groundwater flow to the south. Flow and transport boundary conditions will be set along the flow domain boundary and at sinks/sources within the flow domain. The final model domain may be revised as dictated by the results of the field investigation.

Table 2-4 presents the parameters needed to run the FEMWATER model and the source of the input parameters that will be used. All of the parameters listed in the site conceptual model tables and the model boundaries and layers presented on the figures are preliminary estimates and will be adjusted after the aquifer tests are performed and during the modeling process based on sensitivity tests of the model parameters. Although hydraulic conductivity and specific yield values are presented in the VOC FS (CH2M HILL, 1999), the range of values for hydraulic conductivity is too broad to be used in this study.

The hydraulic conductivity values were derived basewide and more site-specific data are needed for the model. One constant rate pumping test was conducted in EW-366 north of the area in the B monitoring zone (Table 2-5).

The groundwater flow model will be constructed and calibrated after the soil and groundwater sampling and aquifer tests are completed. The initial model calibration will use at least four quarters of groundwater elevation measurements from the surrounding wells and the results from the aquifer tests.

2.5.2 Site Conceptual Parameters for the Analytical Soil Vapor Model – VENT 2D

The analytical soil vapor model VENT 2D was chosen to simulate soil vapor extraction in the newly created vadose zone and existing vadose zone after the A monitoring zone is dewatered. VENT 2D will be used to simulate the effects of multiple SVE and injection wells; initial permeability and contaminant distributions can be simulated. VENT 2D simulates VOC concentrations partitioning into the vapor, dissolved, adsorbed, and nonaqueous phase liquid (if concentrations are high enough).

The model extent is presented on Figure 2-7. Table 2-6 presents the parameters needed to run VENT 2D and the source of the input parameters. The bottom of the simulated vadose zone will be the final configuration of the newly created vadose zone simulated using the groundwater model, added to the current vertical extent of the vadose zone in the test area. All of the parameters listed in Table 2-6 and the model boundary presented on Figure 2-7 are preliminary estimates. The parameters will be adjusted after the local bulk density and TOC soil samples are collected and analyzed, and during the modeling process based on sensitivity tests of the model parameters. Although ranges of data are listed in Tables 2-5 and 2-6, these are preliminary estimates from basewide measurements at other sites. Parameters identified as data gaps in the last column are expected to have an impact on model results and will be measured locally at the test area.

Table 2-5. Input Parameters for FEMWATER

Parameter	Range of Data	Source of Data or Data Gap
Saturated hydraulic conductivity (K) of the A monitoring zone	0.76 to 160 ft/day	CH2M HILL VOC FS, 1999. Data Gap because site-specific data needed.
Saturated hydraulic conductivity of the B monitoring zone	15.5 ft/day (1.8 to 50 ft/day)	Pumping test for EW-366 in northern OU B / CH2M HILL VOC FS, 1999. Data Gap because site-specific data needed.
Specific yield of the A monitoring zone	0.1	CH2M HILL VOC FS, 1999. Data Gap because site-specific data needed.
Specific yield of the B monitoring zone	$1.1 \times 10^{-3} / 7 \times 10^{-5}$	Pumping test for EW-366 in northern OU B / CH2M HILL VOC FS, 1999. Data Gap because site-specific data needed.
Bulk density of the material (g/cc)	1.35 to 1.4	Data Gap because site-specific data needed.
Distribution coefficient of TCE	0.297	Radian International, 1997
Longitudinal dispersivity	0.50 m	Radian International, 1997
Transverse vertical dispersivity	0.005 m	Radian International, 1997
Molecular diffusion coefficient (TCE)	7.6×10^{-10} m/s	Radian International, 1997
Porosity	0.25 to 0.4	Radian International, 1997. Data Gap because site-specific data needed.
Well extraction rate	—	Data Gap – will be determined by model simulation.

FS = feasibility study
ft/day = feet per day
g/cc = grams per cubic centimeter
m = meter
s = second
TCE = trichloroethene
VOC = volatile organic compound

Table 2-6. Input Parameters for VENT 2D

Parameter	Range of Data	Source of Data or Data Gap
Unsaturated soil permeability (m^2)	1.3×10^{-10} to 6.5×10^{-10}	Radian International, 1997. Data Gap because site-specific data needed.
Well extraction rate	—	Calculated for each well
Contaminant soil concentrations (mg/kg)	—	Data Gap – will be based on analytical calculations based on the amount of VOCs in the A monitoring zone and the volume of the newly created vadose zone
Free air diffusion coefficient for TCE (m^2/s at 20°C)	10^{-9}	Pankow and Cherry, 1996
Solubility of TCE (mg/L)	1,100 to 1,384.9	Pankow and Cherry, 1996
Vapor Pressure of TCE (mm Hg)	58 to 75	NIOSH, 1997; Pankow and Cherry, 1996
Porosity of the material	0.3	Radian International, 1997. Data Gap because site-specific data needed.
Moisture content	0.05 to 0.2	Radian International, 1997
Soil bulk density	1.35 to 1.49	Radian International, 1997. Data Gap because site-specific data needed.
Fraction of organic carbon	0.002 to 0.01	Radian International, 1997. Data Gap because site-specific data needed.

C = Celsius temperature
m = meter
m^2/s = meters squared per second
mg/L = milligrams per liter
mm Hg = millimeters of mercury
TCE = trichloroethene
VOC = volatile organic compound

3.0 TECHNOLOGY DESCRIPTION

The purpose of this section is to describe an Aggressive Remediation Strategy being developed to reduce life cycle clean up costs at McClellan AFB. The following subsections describe two of the technologies that will be evaluated as part of the proposed Aggressive Remediation Strategy.

3.1 PRINCIPLES OF TECHNOLOGY

The aggressive remediation strategy being evaluated is comprised of two specific technologies: aggressive dewatering with SVE and *in situ* oxidation. The aggressive remediation strategy will be compared with more conventional methods of remediation to determine if a substantial reduction in costs and time to clean up could be achieved.

3.1.1 Aggressive Dewatering with SVE

The objective of aggressive dewatering is to extract groundwater from a portion of the saturated zone until it is no longer saturated. After the zone is unsaturated, the residual VOC contamination that remains adsorbed to soil or dissolved in residual moisture in the new vadose zone can then be volatilized and caused to migrate using SVE. After aggressive dewatering and SVE have been stopped, the area will resaturate and pump and treat will continue until cleanup levels are reached. However, the test area will not actually be dewatered during the work conducted under this test. Instead, the feasibility of dewatering will be determined using vadose zone and groundwater models. The models will be used to simulate dewatering followed by SVE to determine the time to clean up. Conventional groundwater extraction will also be modeled. An economic analysis of dewatering an aquifer then using SVE will be compared to only groundwater extraction and treatment. Aggressive dewatering will be considered an effective strategy if costs of dewatering with SVE are substantially reduced compared to the more conventional methods of remediation.

The following parameters will be assessed to determine if it is economically feasible to dewater a portion of the saturated zone:

- The permeability of lithologic layers at the bottom of the water table in the study area;
- The lateral extent of the saturated zone in the test area; and,
- The cost of mass removal.

The above conditions are critical for the following reasons. The saturated zone must be bounded at the bottom by impermeable or semi-permeable lithologic layers. If groundwater recharges the zone from below, then dewatering will not be economically feasible due to the large volume of water that needs to be extracted. The lateral extent of the saturated zone should be of a size that the groundwater volume extracted from it during the dewatering process is economically feasible to remediate. Finally, the costs of the mass removal rate of VOCs with dewatering, vacuum extraction, and treatment must be substantially less than more conventional treatments such as extraction and treatment.

To obtain the permeability and lateral extent data, several soil borings will be drilled and aquifer tests will be performed. The data will be used to develop a site conceptual model used for the groundwater and

vadose zone numerical and analytical models. The models will be used to simulate aggressive dewatering and SVE at the site to evaluate feasibility of dewatering and potential cost reductions in long-term groundwater cleanup. The aquifer tests and modeling approach are discussed below.

The hydraulic conductivity and specific yield values generated from the results of the aquifer tests will be compiled in the site conceptual model. Information from the site conceptual model and aquifer test data will be used to construct the numerical groundwater model and the analytical models, and in the case of numerical models to calibrate the dewatering models. Results from the dewatering model and the site conceptual model will be used to construct the SVE model. Modeling of aggressive dewatering and SVE will be undertaken in four stages:

- Stage 1 – Finite Element Groundwater Flow Model. Aggressive dewatering of a predetermined volume of groundwater from the A monitoring zone at the site will be modeled using the numerical, finite element, groundwater flow model FEMWATER.

- Stage 2 – Vadose Zone Vapor Extraction Model. Contaminant removal using vapor extraction of the newly created vadose zone at the site will be modeled using the 2-dimensional soil vapor (vadose zone) extraction model VENT 2D.

- Stage 3 – Analytical Model. An analytical model will be applied after the aggressive dewatering and vadose zone extraction models (Stages 1 and 2) to estimate the amount of VOC mass that would be left in the vadose zone after dewatering and SVE are stopped and to determine the contaminant concentrations in the groundwater in this area for Stage 3 of the modeling.

- Stage 4 – Finite Element Groundwater Transport Model. Resaturation of the dewatered zone, contaminant equilibration, and contaminant transport under conventional pump and treat of the A monitoring zone in the outlined area after the aggressive dewatering will be modeled with FEMWATER using the same finite element groundwater flow and contaminant transport grid as in Stage 1.

The goal of the staged modeling is to evaluate if the aggressive dewatering technology can reduce the time of cleanup of VOCs in groundwater at this site or at other sites on McClellan AFB. In order to compare costs of aggressive dewatering and SVE to conventional pump and treat technologies, Stages 2 through 4 of the model will be rerun in an iterative process to generate comparative data. A graph will be prepared presenting the estimated cost per pound over time. The second through fourth modeling stages will be run iteratively until the simulation results indicate the aggressive dewatering and SVE technology have completely reduced the concentration of VOCs in the groundwater to concentrations below MCLs. A comparison curve showing costs of using conventional pump and treat technology will be added to the graph.

3.1.2 *In Situ* Oxidation

In situ oxidation is a technology in which an oxidant is injected in groundwater to promote breakdown of the contaminants through oxidation. For this study, the injected oxidant liquid will consist of a 10% strength catalyzed hydrogen peroxide.

Concentrated hydrogen peroxide has been used to treat soil and wastewater for organic compounds for many years. Previously this oxidation was performed in an above grade reaction chamber. When properly injected into the subsurface, concentrated hydrogen peroxide (>3%) reacts with naturally occurring ferrous iron ion (Fe^{2+}) to produce the hydroxyl radical (OH^-) commonly known as Fenton's reagent. The hydroxyl radical is a very strong oxidizer for a wide range of organic compounds and will breakdown hydrocarbons to carbon dioxide and water, typically within a few minutes. TCE is easily oxidized as olefins are very susceptible to chemical oxidation by opening of the double bonds. Heat is formed as a result of the oxidation. Hydrogen peroxide will degrade to water and oxygen, eliminating any concern of its continuing presence in the subsurface. Hydrogen peroxide is known to react with iron (both ferrous and ferric) and organic compounds in a variety of competing reactions including:

1) $H_2O_2 + Fe^{2+} \rightarrow Fe^{3+} + OH^- + OH^-$

2) $H_2O_2 + Fe^{3+} \rightarrow Fe^{2+} + H^+ + HO_2^-$

3) $RH + OH^- \rightarrow H_2O + OH^-$

4) $Fe^{2+} + OH^- \rightarrow ROH$

5) $R + Fe^{3+} \rightarrow Fe^{2+}$ + products

6) $R + OH^- \rightarrow ROH$

7) $R + H_2O_2 \rightarrow ROH + OH^-$

8) $HO_2^- + Fe^{3+} \rightarrow O_2 + Fe^{2+} + H^+$

9) $OH^- + H_2O_2 \rightarrow HO_2^- + H_2O$

Hydroxyl radical reactions with organic compounds are rapid and have rate constants in the range of 10^7 to 10^{10} L-mols/s. The oxidative potentials of the hydroxyl radical intermediates are second only to fluorine. It has been speculated that the free radicals formed by Fenton's process in soil systems at pH <6 are the primary in-situ oxidizing species shown in (3) and (6).

Because Fenton's reagent is a strong, non-specific oxidizer, the amount of soil organic matter will compete for consumption of hydrogen peroxide. Excess H_2O_2 is required to oxidize target compounds in addition to the dose consumed by self-decomposition and oxidation of non-target materials.

3.2 WASTE AND MEDIA APPLICABILITY

These technologies are only applicable to *in situ* treatment of VOC contamination in soil and groundwater.

3.3 ADVANTAGES AND DISADVANTAGES/LIMITATIONS

The goal of this project is to develop and assess aggressive remediation strategies that show substantial reductions in life cycle costs through a reduction in the projected time to clean up VOC contamination in

soil and groundwater. Following are advantages and disadvantages that have been identified for the aggressive dewatering and *in situ* oxidation technologies.

Advantages

The proposed aggressive remediation strategy has the following advantages over conventional groundwater extraction:

- Soil vapor is less costly than groundwater to treat.
- VOC mass in soil gas can be removed more rapidly than in groundwater.
- The *in situ* oxidation technology targets destruction of the VOC mass *in situ*.
- The overall time and cost of cleanup would be reduced because the *in situ* oxidation technology results in faster *in situ* degradation of organic compounds.

Disadvantages/Limitations

Potential disadvantages of the aggressive remediation strategy are as follows:

- Pumping and treating large quantities of water will be costly.
- The use of *in situ* oxidation enhanced extraction may not be cost effective for low-concentration sites.
- The effective zone of degradation for *in situ* oxidation is dependent on site-specific conditions.
- Competitive consumption of ferrous ions may occur for *in situ* oxidation. However, the concentration of ferrous ion is monitored and added to the peroxide, if needed, prior to injection.

3.4 DEVELOPMENT STATUS

A very limited amount of data exists to support the practicality of the aggressive remediation strategy. However, the aggressive remediation strategy may be taken to demonstration and validation at full-scale. Multi-phase extraction is a similar technology that may be compared with aggressive dewatering coupled with SVE. The individual components of aggressive dewatering coupled with SVE are "commercial off-the shelf" (COTS) items.

In situ oxidation has been implemented at multiple sites on a pilot scale basis and hydrogen peroxide has been shown to be effective at reducing both high and low concentrations of VOCs. Fenton's Reagent has been used by some vendors to reduce low concentrations (less than 100 µg/L) of trichloroethane (TCA) by 40% in just eight months. The time to achieve the reduction was much less than the time anticipated to operate the conventional groundwater pump and treat system at the site and achieve the same reduction. *In situ* oxidation has been implemented at several similar sites and is ready for demonstration at McClellan AFB.

4.0 OBJECTIVES

The following are the objectives of the aggressive remediation strategy at McClellan AFB.

4.1 GENERAL OVERVIEW

The objective of this project is to assess an aggressive remediation strategy that offers a significant reduction in the life cycle costs at this site or other applicable sites at McClellan AFB. The remediation strategy's purpose is to reduce the projected time to reach clean up goals for VOC contamination in soil and groundwater. The strategy that will be evaluated is comprised of aggressive dewatering followed by SVE and *in situ* oxidation.

4.2 DESCRIPTION OF TECHNOLOGY PROCESS

The aggressive remediation strategy will apply aggressive dewatering with SVE and *in situ* oxidation to remediate VOCs in soil and groundwater. The process of the aggressive dewatering is to extract groundwater from an aquifer zone until the zone is completely or partially dewatered. This is followed by SVE of the newly dewatered zone to remove residual VOCs.

The process of the *in situ* oxidation technology is to inject oxidant into an aquifer via wells located in a perimeter and then extract groundwater from a well located in the center of the perimeter wells. This will draw the oxidant through the aquifer toward the center where the extraction well is pumping. VOC and oxidant concentrations are sampled and pH, redox, and dissolved oxygen are measured prior to, during, and after oxidant injection to monitor these parameters. One or both of these technologies will comprise an overall aggressive remediation strategy to reduce the life cycle costs and projected time to clean up for VOC contamination.

4.3 STATEMENT OF DEMONSTRATION'S OBJECTIVES

The ultimate goal of this project as stated in Section 4.1 is to develop and assess an aggressive remediation strategy that offers a substantial reduction in the life cycle costs and in the overall time to clean up at this site or other applicable sites at McClellan AFB. To evaluate if the aggressive remediation strategy will reduce lifecycle costs and time to cleanup, the feasibility (technological and economic) of aggressive dewatering with SVE and an *in situ* oxidation technology will be considered.

The following specific measurable objectives have been identified for this project:

- Collect aquifer characteristic data from aquifer tests to be used in the groundwater model FEMWATER and the SVE model VENT 2D to assess the economic feasibility of using aggressive dewatering with SVE as a remedial alternative for VOC-impacted groundwater sites at McClellan AFB. Modeling will be performed to obtain the following objectives that are explained in detail in Section 4.4:
  - — Determine "time to cleanup" under the existing remediation plan, design placement/rate of dewatering wells, and to estimate time to dewater by modeling groundwater flow.
  - — Estimate mass removal of soil vapor over time.
  - — Determine the new time to clean up by modeling groundwater flow and transport.

- Evaluate if *in situ* oxidation is a technically and economically feasible alternative for remediation of groundwater at McClellan AFB.

- The costs of the aggressive remediation strategy (*i.e.*, aggressive dewatering with SVE using modeling results and of *in situ* oxidation) will be compared to the costs of conventional groundwater extraction and treatment to evaluate if there is a substantial reduction in the life cycle clean up costs. Quality cost related data from using conventional groundwater extraction and treatment and or dual phase at McClellan AFB must be collected from Environmental Management (EM) at McClellan AFB so that it may determined if the aggressive remediation technologies can substantially reduce life cycle costs. These costs will include but are not limited to material storage, waste storage and/or transfer and treatment, utilities and capital costs for materials.

4.4 TEST PLAN

The following steps will be taken to implement the aggressive remediation strategy. Figure 4-1 presents the scheme for the aggressive remediation strategy described in this WIP. Field activities to fill data gaps will be performed (see detailed discussion in Section 5.0). The groundwater flow model FEMWATER and the vapor extraction model Vent 2D will be used to simulate aggressive dewatering with SVE using data obtained from the field investigation. The objective of using the models is to evaluate the aggressive dewatering and SVE technology to assess the time and materials (*e.g.*, wells, pipelines, etc.) required for reduction in the mass of VOCs resulting in a shorter time to remediate the groundwater. The modeling will be performed in four stages: dewatering, SVE, analysis, and resaturation with groundwater extraction of the test area. Estimated costs for these stages can then be compared to the estimated life cycle costs to clean up the site using conventional extraction and treatment or dual-phase technology. The models will be used to assess the amount of time and the mass of contaminant that is removed during each stage of the aggressive dewatering demonstration.

Stage 1 – Finite Element Groundwater Flow Model

The finite element model FEMWATER will be used for the first stage of modeling because the extraction wells can be located on the nodes of the model to more accurately simulate the drawdown of the groundwater extraction wells. The groundwater flow model will be used to assess the following:

- Number, location, and optimal pumping rate of extraction wells screened in the A and B monitoring zones.

- Number and location of monitoring wells or piezometers to assess the success of the dewatering process.

- Predict the amount of time necessary to dewater the test area.

- Estimate the volume of water that will be removed to keep the area dewatered.

- Estimate (coupled with analytical calculations) the concentration of contaminant as residual in the new vadose zone.

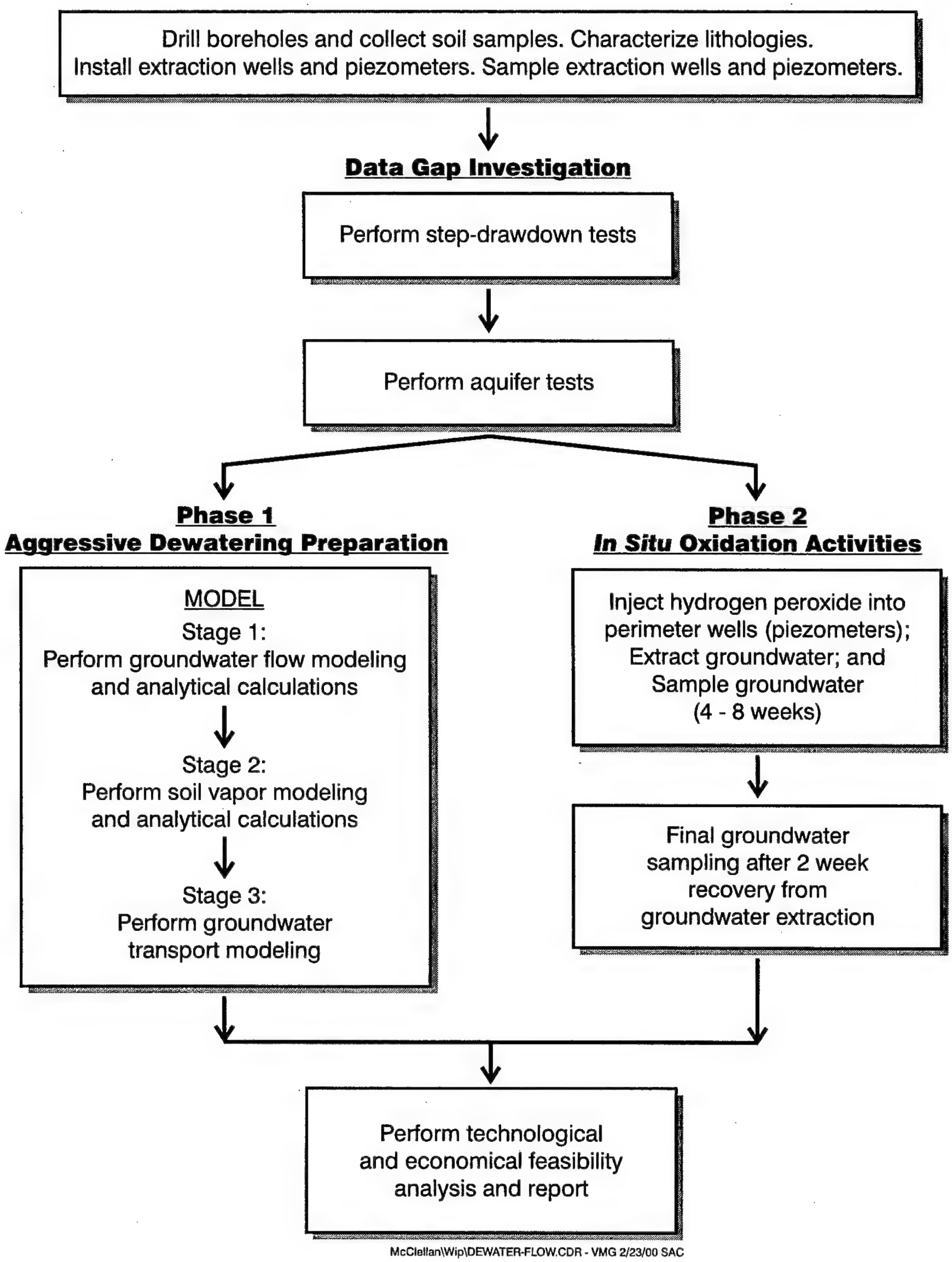

Figure 4-1. Aggressive Remediation (Aquifer Test and *In Situ* Oxidation) Activities Flow Diagram

Aquifer parameter data such as the hydraulic conductivity and specific yield of the aquifer material must be calculated from aquifer tests on the site in the A and B monitoring zones. The values will be used for calibration and as input data into the groundwater flow model.

Stage 2 – Vadose Zone Vapor Extraction Model

VENT 2D will be used as the SVE model, because it is capable of simulating the effects of multiple SVE wells. The vapor extraction model will be used to estimate mass removal rates and the radius of influence of vapor extraction wells in the dewatered A monitoring zone (unsaturated soil) and the existing vadose zone. The vadose zone vapor extraction model will be used to assess the following:

- Number, location, and ideal extraction rate of the SVE wells.
- Rate of mass removal of VOCs.
- Residual amount of mass of contaminants in the vadose zone at any time after the end of the dewatering phase.

Input parameters to the vadose zone vapor extraction model in Section 2.5 and will include properties of the chemicals of concern for example, gas, solubility, vapor pressure, and free-air diffusion coefficient of VOCs, and soil properties such as the total organic carbon content, soil bulk density, thickness of vadose zone, porosity, and moisture content. Many of these parameters will be supplied by the *Remedial Investigation General Framework Report,* Appendix B (Radian International, 1997).

Stage 3 – Analytical Model

An analytical model will be applied after the aggressive dewatering and vadose zone extraction models (Stages 1 and 2) to estimate the amount of VOC mass that would be left in the vadose zone after dewatering and SVE are stopped and to determine the contaminant concentrations in the groundwater in this area for Stage 4 of the modeling.

Stage 4 – Finite Element Groundwater Transport Model

The fourth modeling stage will simulate contaminant transport after the A monitoring zone is resaturated. This stage of modeling will use the same model used during Stage 1 modeling. This modeling stage will be used to determine the fate and transport of the contaminants in the newly resaturated vadose zone. The objectives of this modeling phase will be to evaluate the following:

- Time to clean up groundwater to below the MCL (or other specified criteria) in the A zone after the zone is resaturated.
- Use model results to estimate clean up costs for the A monitoring zone using aggressive dewatering as compared to conventional pump and treat.

The following steps will be taken to implement *in situ* oxidation: hydraulic capture will be confirmed and hydrogen peroxide will be injected into the three A zone piezometers. To minimize hydraulic dilution and hydraulic mounding, small but numerous pulses of oxidant will be injected. Air sparging will be

performed after each injection to promote mixing and spreading of the oxidant. During this time, samples will be collected from the extraction well to measure indications of *in situ* oxidation (see Figure 4-1).

Upon detecting concentrations of residual peroxide in samples from the extraction well of approximately tens of parts per million (ppm) and other activity indicators (such as redox and pH if appropriate and dissolved oxygen), the extraction well will be shut down for two weeks and the aquifer will be allowed to recharge. Then the extraction well will be restarted and samples will be collected and analyzed for VOCs over a period of 10 weeks.

A cost analysis will be done comparing the aggressive remediation strategy results to conventional pump and treat. If it is determined that aggressive dewatering and/or *in situ* oxidation are technologically and economically feasible and fulfill the objective of this project, a follow-on treatability study may be performed at McClellan AFB.

4.5 TECHNOLOGY PARAMETERS EVALUATION

Technology factors that can affect the performance of the treatment process can fit into three categories:

(1) Performance evaluation parameters.
See Section 8.1 for a description of performance evaluation parameters.

(2) Chemical operating parameters.
See Sections 8.4.2, 8.5, and 8.7 for a description of chemical operating parameters.

(3) Physical operating parameters.
See Sections 5.2, 5.3, 8.6, and 8.8 for a description of physical operating parameters.

4.6 DATA ANALYSIS AND INTERPRETATION

To fulfill the goals of the aggressive remediation strategy, the following data will be collected and analyzed:

Soil Sampling Data

Soil samples will be collected from the vadose zone and the A monitoring zone and analyzed for soil bulk density and total organic carbon (TOC) to be used as input parameters to the groundwater and vadose zone models. The results from both the bulk density and TOC analyses will be used to calculate an average value as input into the groundwater and vadose models. If any of the results from the analyses are outside the range of values presented in the RI General Framework (Radian International, 1997), they wil`l be evaluated to determine if they are appropriate to include in the average.

Aquifer Testing

Data obtained during the aquifer testing will be analyzed using the Hantush curve fitting method for leaky aquifers (Kruseman and deRidder, 1991) for hydraulic conductivity and specific yield values.

Water Levels

Water level measurements will be collected to determine hydraulic response and capture during groundwater pumping.

Groundwater Sampling Data

Groundwater sampling results for VOCs will be incorporated into a contaminant mass calculation to assess the mass present in the test area, and by plotting concentrations on a plan view map of the test area and drawing isopleths to delineate contamination at the test area.

Collect groundwater samples and analyze for TOC, total suspended solids (TSS), and total carbonate to determine geochemistry of the aquifer prior to oxidant injection.

Collect and analyze groundwater samples prior to, during, and after oxidant injection to measure change in TCE concentration and activity indicators of *in situ* oxidation. The activity indicators are oxidation reduction potential (ORP), dissolved oxygen (DO), and temperature, pH, and conductance.

Observing trends in contamination over time to determine the effectiveness of the *in situ* oxidation technology.

Statistical analysis of data will occur as follows:

Vadose Zone and Groundwater Model Sensitivity Analyses

Model input parameters for the vadose zone and groundwater models will be varied by at least 20%, greater than and less than the average value (or the range shown on Tables 2-4 and 2-5) in order to assess how sensitive the model output is to each parameter. The sensitivity analyses can be used to place error limits on the model estimated time to clean up and the amount of mass removed. The sensitivity analyses for the vadose zone model will be performed for, but not limited to, the porosity, moisture content, soil bulk density, contaminant concentrations, and the well extraction rates. The sensitivity analyses for the groundwater model will be performed for, but not limited to, the porosity, hydraulic conductivity, specific yield, dispersivity, molecular diffusion, and the well extraction rates.

Statistical Evaluation of *In Situ* Oxidation Groundwater Sample Data

Data evaluation for the *in situ* oxidation portion of the test will include an initial graphical evaluation (*i.e.,* concentration time series for each location sampled, summary statistics) to evaluate changes in VOC concentrations throughout the duration of the test. The concentration data will also be statistically evaluated using appropriate procedures.

Ideally, a means comparison using a parametric statistical method will be used to compare baseline and final concentrations. However, if the data do not meet the statistical assumptions for parametric statistical tests, then non-parametric statistical tests will be used to evaluate the data. First the data will be evaluated to determine if a non-parametric two sample ranks test such as the Mann-Whitney test is appropriate for analysis. If the data do not support the assumptions for the Mann-Whitney test, then another type of non-parametric test (*e.g.,* the Kruskal-Wallis test of the equality of medians or the Mood's median test) may be appropriate to the data.

Because of the relatively small number of sample locations for this study, empirical analysis and observations, such as time series plots and one-to-one baseline and final concentration comparisons may prove to be the most effective means to assess the outcome of the study.

5.0 FIELD ACTIVITIES

The field activities necessary to complete the evaluation of the aggressive remediation strategy include closing the data gaps at the test area, performing aquifer tests, and implementing the *in situ* oxidation test. These field activities are described in the following six subsections:

- Pre-Operation Characterization.
- System Installation.
- System Operation.
- Material Storage.
- Residuals Management.
- De-mobilization and Site Restoration.

5.1 PRE-OPERATION CHARACTERIZATION

The hydrogeology and contaminant distribution in the test area are not completely defined because only one deep boring has been drilled that can be used for lithologic interpretation (see Appendix A). As previously stated in the site geology and hydrogeology sections, the one soil boring drilled near the site (MW-451) indicates that a silt layer is present at the bottom of the A monitoring zone at 157 feet bgs and extends almost completely through the B zone to about 200 feet bgs. This silt layer may provide a low permeability layer that could confine the B monitoring zone and allow economic dewatering of the A zone. However, additional soil borings are necessary to determine the lateral and vertical continuity of the silt layer. The following are the data gaps identified for the test area:

- Characteristics and lithology of the vadose zone and the A, B, and C monitoring zones across the site.
- Continuity or existence of a horizontal boundary between the A and the B monitoring zones and between the B and the C monitoring zones. The silt layer between the A and B monitoring zones may not be laterally continuous or sufficient for dewatering.
- Degree of hydraulic communication between the A and B and the B and C monitoring zones.
- Hydraulic characteristics of the A and B monitoring zones that would influence flow simulations.
- Contaminant distribution and concentration in the A and B monitoring zones.

In order to assess if aggressive dewatering at this site is economically viable it must be determined if there is any type of confining layer separating the A monitoring zone from the lower monitoring zones within the test area. Therefore, all five of the soil borings will be drilled into the C monitoring zone to

assess if a confining layer exists between the A and B monitoring zones. The specific field activities are as follows:

- Two soil borings will be drilled and extraction wells will be installed in the center of the test area. One extraction well will be screened in the A monitoring zone and one will be screened in the B monitoring zone. Both soil borings will be drilled to a depth of approximately 282 feet bgs. The boreholes will be drilled using mud rotary with continuous wireline coring and wireline geophysical logging in order to obtain accurate lithologic descriptions for the entire length of the boreholes. The lithology will be used to assess the optimum placement of the well screens and used to evaluate the presence of an aquitard between the A and B monitoring zones. At least two weeks after the extraction wells are installed aquifer tests will be conducted as described in Section 5.3. Extraction wells are needed in both the A and the B monitoring zones to assess the effects of pumping on each zone individually and to monitor the effects of pumping both zones simultaneously on the A, B, and C zone. The A, B, and C zone piezometers will be installed as described below.

- Three soil borings will be drilled into the C monitoring zone. Nested piezometers screened in the A, B, and C monitoring zones will be installed into each borehole. The piezometer nests will be used to monitor the aquifer tests described in Section 5.2.2. The piezometer nests will be located surrounding the extraction wells and will be logged and evaluated for aquitards as described above. One piezometer nest will be installed about 20 to 25 feet downgradient of the extraction wells. One piezometer nest will be installed about 44 to 46 feet cross gradient of the extraction wells, and one piezometer nest will be installed about 60 to 80 feet upgradient of the extraction wells.

Field activities are presented in Table 5-1. Figure 5-1 shows proposed locations for the soil borings for the extraction wells and piezometers. Borehole locations may change depending on the effect of extraction wells installed during 1999 under Phase 2 of the Groundwater Operable Unit (GWOU) Phase 2 Work Plan on the groundwater gradient (CH2M HILL, 1997). Water level measurements after at least four quarters of operation of the Phase 2 wells should reflect the changes in the groundwater gradient; therefore, water level data from the second quarter of 2000 or later can be used.

Based on experience at McClellan AFB, the depth at which groundwater is encountered during the drilling of the borehole may be different than the final water table in the borehole. Geologists experienced with the stratigraphy at McClellan AFB will describe the drilling of the boreholes. A registered geologist with previous experience in well installation at McClellan AFB will oversee all drilling activities.

Excess water and soil cuttings generated during the field investigation will be disposed in accordance with SOP No. McAFB-013 (Radian International, 1999c). Wastewater will be stored in wastewater storage tanks and discharged into the McClellan AFB Groundwater Treatment Plant or CERCLA Wastewater Treatment Plant or disposed of at approved treatment or disposal facilities. Soil cuttings will be collected in bins drums, labeled, sampled, and transferred by a McClellan AFB contractor to a designated location for treatment and disposal.

Table 5-1. Proposed Soil Borings/Wells

Proposed Borings/Wells	Monitoring Zone of Screen	Rationale
WIPSB01 / EW A	A	Soil borings are needed to obtain additional lithologic data for the test area to determine hydraulic communication between the A and B monitoring zones and select screen intervals for wells.
WIPSB02 / EW B	B	
WIPSB03 / PZ 1A	A	
PZ 1B	B	
PZ 1C	C	
WIPSB04 / PZ 2A	A	Two extraction wells (one in the A zone and one in the B zone) will be constructed in the approximate center of the area identified as having the longest time until cleanup (CH2M HILL, 1997). Piezometers will be located around the extraction wells at distances of 20–25 feet downgradient, 44–46 feet crossgradient, and 60–80 feet upgradient of extraction wells. Extraction wells are needed in the A and B zones so that effects of pumping on the A and B zones separately and the effects of pumping both zones together may be monitored in the surrounding piezometers. The piezometers also serve as measuring points during the aquifer tests.
PZ 2B	B	
PZ 2C	C	
WIPSB05 / PZ 3A	A	
PZ 3B	B	
PZ 3C	C	

Field investigations will require coordination with McClellan AFB Environmental Management Restoration Division (EMR) at least 30 days in advance of all field efforts. Logistical concerns that must be considered include field activities within or adjacent to roads, parking lots, active work areas, or any other area where field crews may potentially disrupt base operations. When field activities are performed in close proximity to buildings or in parking areas, the building manager/supervisor will be notified in writing by EMR prior to the scheduled work.

5.2 SYSTEM INSTALLATION

5.2.1 Well Construction Details

As described in Section 5.1, 11 wells will be installed within the test area (two extraction wells and nine piezometers). All of the wells will be utilized for the aquifer tests that will provide data to be used for modeling. Additionally, all the A zone wells will be used to perform the *in situ* oxidation test.

One boring will be drilled to a depth of 120 to 145 feet bgs, and an extraction well installed in the boring screened in the A monitoring zone. The second extraction well will be screened in the B monitoring zone between 150 to 200 feet bgs. The screen intervals of the wells will be determined in the field from the lithologies encountered during drilling activities. The wells will be constructed with Schedule 40 polyvinyl chloride (PVC), 6-inch diameter casing and screen. Screen length, slot size, and filter pack grain size depend on lithologies and will be determined during drilling activities.

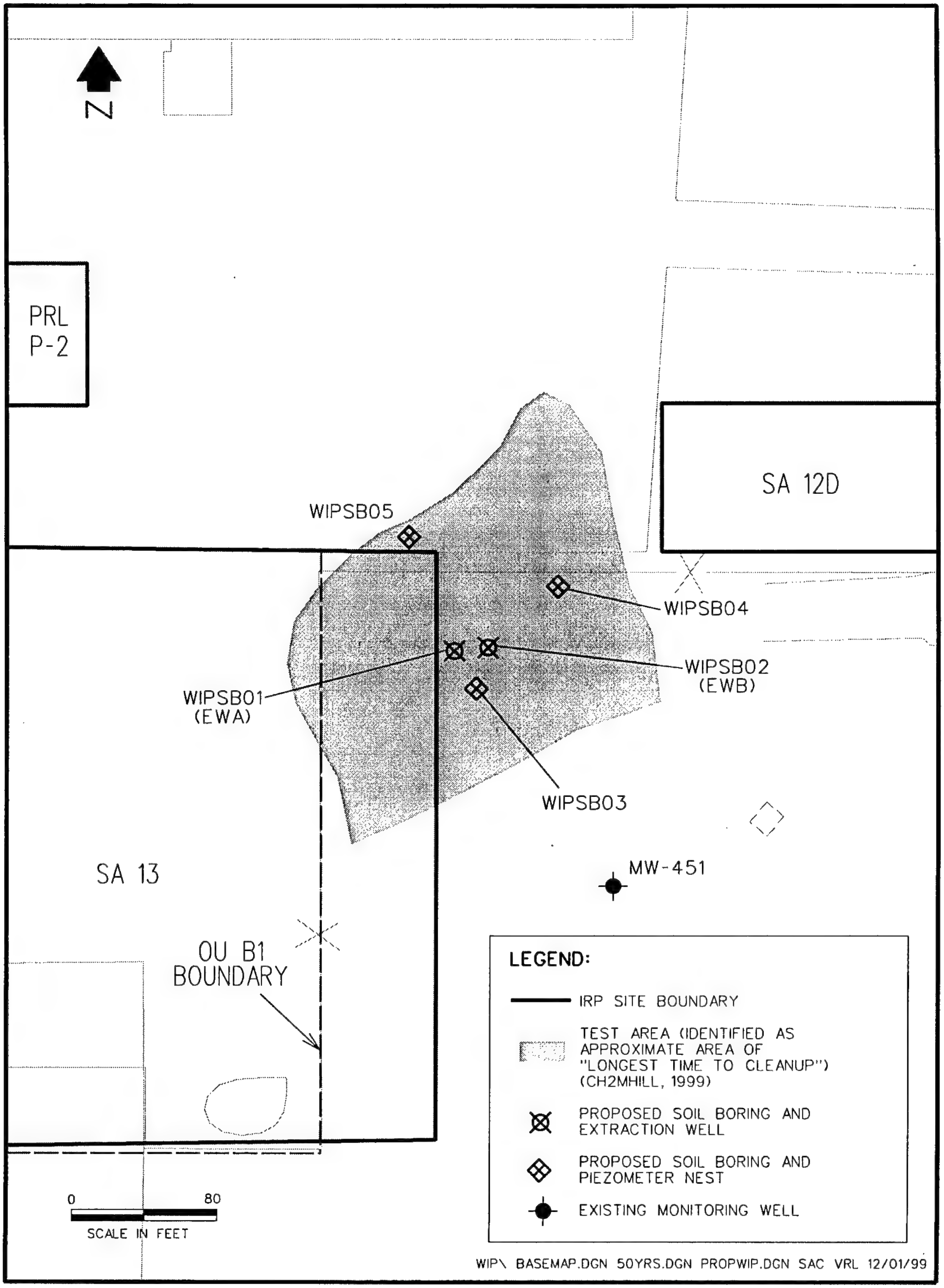

Figure 5-1. Proposed Locations for Soil Borings, Extraction Wells, and Piezometers

As with extraction well construction, the screen intervals of the piezometers, slot size, and filter pack grain size depends on the lithology encountered and will be determined during drilling activities. All piezometers will be constructed with Schedule 40 or Schedule 80 PVC, 1- to 2-inch diameter casing and screen. Screens of all piezometers will be 2 to 5 feet long. Well construction details of extraction wells and piezometers may change depending on geologic conditions encountered during drilling activities.

The mud rotary drilling method with continuous wireline coring followed by wireline geophysical logging will be used for the field project. This drilling technique forces a drilling fluid through a center drill pipe and out through ports or jets in the drill bit at the bottom of the hole. Drill cuttings carried to the surface suspended in the drilling fluid. All drilling procedures will comply with the procedures outlined in SOP McAFB-004 (Radian International, 1999c). All well installation procedures will comply with the procedures outlined in SOP McAFB-004 (Radian International, 1999c).

5.2.2 Aquifer Testing

There are two parts to the aquifer testing. First, step-drawdown tests will be performed in the A and B zone extraction wells. Data collected during the test will be used to select an optimal pumping rate to be used for each well during the constant rate aquifer tests and during extraction for the *in situ* oxidation test. The second part of aquifer testing is three constant rate aquifer tests.

Aquifer pumping test data are needed to calculate the aquifer parameters such as hydraulic conductivity and specific yield for the A and B monitoring zones, and also to determine extraction well locations for the groundwater model. The aquifer tests will also be used to determine the hydraulic communication between the A and B, and B and C monitoring zones. Therefore, one extraction well screened in the A zone and one in the B zone and several piezometer nests are necessary to perform the aquifer tests. The extraction wells will also be used as extraction wells for *in situ* oxidation (Section 5.5). Three piezometer nests are needed surrounding the A and B zone wells for observation of hydraulic effects during the aquifer tests. Three piezometer nests with A, B, and C zone piezometers will also be installed 20 to 25 feet downgradient (south), 44 to 46 feet crossgradient (east-northeast), and 60 to 80 feet upgradient (north-northwest) of the extraction wells used for the aquifer tests. The A zone piezometers will also be used as injection wells for *in situ* oxidation testing (Section 5.5).

Step-Drawdown Test Setup

Step-drawdown tests will be performed in the A and B zone wells to assess the well efficiency and optimum pumping rates for the aquifer tests. For the step-drawdown tests, the extraction wells will be pumped for two hours each step at predetermined rates, or consecutive steps, and the time needed after the last step to recover 99% of the static water level will be recorded. The procedure is described in the Step-Drawdown SOP, McAFB – 043 (Radian International, 1999c).

Field Procedures for Aquifer Tests

An overview of the methods that will be used to set up and implement the tests is presented below. As stated previously, the extraction wells installed in 1999 as part of the Phase 2 Groundwater Operable Unit (GWOU) Phase 2 Work Plan (CH2M HILL, 1997) will have bee operating for four quarters prior to conducting the aquifer tests for this project.

All aquifer tests conducted at the test area will include:

- Monitoring water levels for 72 hours prior to testing;
- Monitor the water level recovery of wells;
- Pumping the extraction well or wells for 72 hours while monitoring water levels in the surrounding A, B, and C zone piezometers;
- Collecting water pumped from the extraction well or wells in tanks and vacuum trucks, and discharging it to the Groundwater Treatment Plant (GWTP); and
- Monitoring recovery in the same wells and piezometers for the same length of time as the extraction well or wells were pumped.

Water levels will be monitored using transducers and a data logger. In addition, water level measurements will be cross-checked using a manual water level meter.

The following aquifer tests will be performed:

- The A zone extraction well will be pumped for at least 72 hours and all of the piezometer nests will be monitored;
- The B zone extraction well will be pumped for at least 72 hours and all of the piezometer nests will be monitored; and
- Both the A and B zone extraction wells will be pumped simultaneously for at least 72 hours and the extraction wells and piezometers will be monitored.

Table 5-2 lists proposed pumping tests and rationale.

Table 5-2. Aquifer Testing

Action	Rationale
Measure water levels in new wells and surrounding wells (MW-132, MW-155, MW-156, MW-164, MW-165, MW-166, MW-217, MW-218)	Baseline water level measurements will allow change in water table showing a hydraulic response to be recorded.
Step Drawdown Tests	The step-drawdown test will be performed on the extraction wells to provide data needed to select the proper pumps and assist in designing aquifer tests.
Aquifer Tests 1. Monitor all piezometers while pumping A zone extraction well. 2. Monitor all piezometers while pumping B zone extraction well. 3. Monitor all piezometers while pumping both A and B zone extraction wells.	Aquifer tests will be performed to provide data to calculate the hydraulic conductivity for each of the A and B monitoring zones and to calibrate the vadose zone and groundwater models when both the A and B zone are pumped.

All measurements taken as part of the test will be recorded on an Aquifer Testing Field Data Sheet. All aquifer testing procedures will comply with the procedures outlined in SOP McAFB-010 (Radian International, 1999c).

Data Downloading

After the aquifer tests are completed, the data recorded by the loggers will be downloaded to a computer using the downloading procedures for the data logger.

Once the data have been downloaded to files on the computer they will be analyzed using either unconfined or leaky aquifer methods as described in Kruseman and de Ridder (1991). The drawdown data collected from the piezometers will be used to construct a distance versus drawdown plot. All of these analyses will be used to derive the hydraulic conductivity and storativity values that will be used as input into the groundwater flow and transport model. The data will also be used to estimate capture zones of the pumped wells and the amount of hydraulic connection between the A, B, and C monitoring zones.

5.2.3 *In Situ* Oxidation

The objective of the *in situ* oxidation demonstration is to collect data to show that oxidant injection may be a viable remediation alternative to more quickly and cost effectively clean up similar sites at McClellan AFB. A set of minimum acceptable conditions will be evaluated as the decision criteria to determine if the *in situ* oxidation test will be implemented at the test site. The conditions are presented on Figure 5-2 and include the following:

- The time necessary to capture all groundwater potentially impacted by the *in situ* oxidation test must be less than one year. Data obtained from the aquifer tests (such as hydraulic conductivity), and from the drilling and sampling of the boreholes (such as the thickness of the aquifer and the porosity of the aquifer material) will be used to determine the amount of time that will be necessary to capture the groundwater potentially impacted by the *in situ* oxidation test.

- To determine if the *in situ* oxidation test will proceed, there must be sufficient concentrations of VOCs in groundwater to perform statistical analysis quantifying the results of the peroxide injection. The results must meet the DQOs set forth in Section 8.0; therefore, a sufficient number of samples must be collected to allow a statistical analysis (stated in Section 4.6) to be performed.

- To determine if the *in situ* oxidation test will proceed, the effects of the pulsed air sparging (used to mix and spread the hydrogen peroxide) must be accounted for using statistical analysis. In other words, a statistical analysis of the sampling data must be able to determine the contaminant degradation due to *in situ* oxidation in addition to effects due to the pulsed air sparging delivery system.

The following rationale will be used to guide the determination of the sampling strategy. The removal rate of VOCs varies throughout the *in situ* oxidation procedure and is a function of the various volumes of peroxide, distribution of VOCs, and other geochemical parameters in the aquifer. The removal rate is

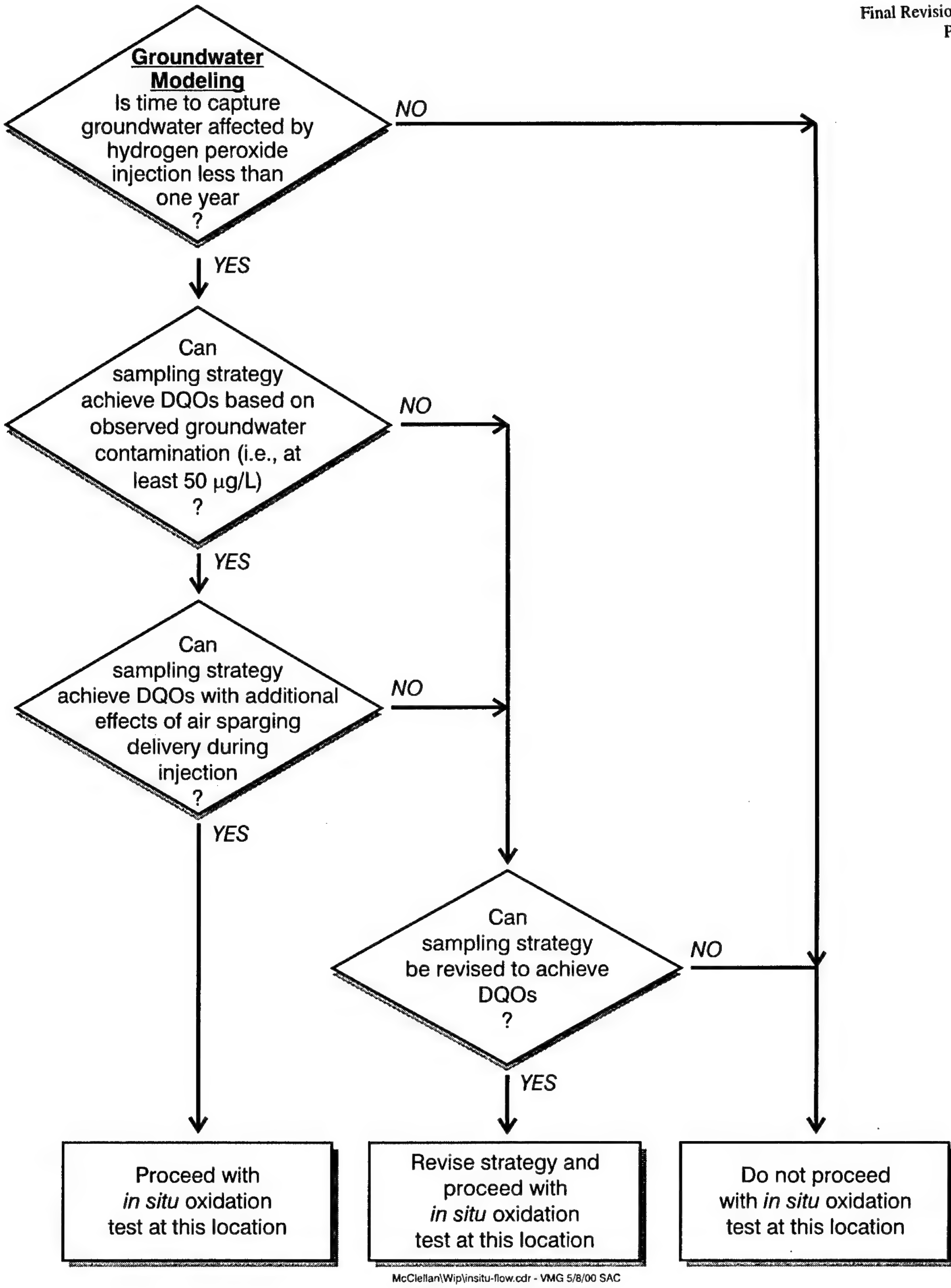

Figure 5-2.
Go/No Go Decision Logic Flow Diagram for *In Situ* Oxidation

also a function of fate and transport (*e.g.* permeability, gradient, pumping rates, the distance between the extraction well and the injection points, etc.). During the *in situ* oxidation test, a decreasing trend of VOC concentrations is first anticipated followed by an increasing trend in VOC concentrations. The initial decrease in VOC concentrations occurs as the hydroxyl radicals resulting from the Fenton's reagent reaction with the peroxide reacts with the VOCs. After the peroxide injection is stopped and the peroxide concentrations decrease (due to degradation, chemical reactions with VOCs and other constituents in the aquifer, and extraction along with the pumped groundwater), concentrations of VOCs begin to increase as they are replenished from upgradient sources. Therefore, groundwater samples will be collected in greater numbers and frequency in the beginning of the test and then decreasing frequency as the test progresses. Initial concentrations of VOCs at the test area (measured prior to the start up of the *in situ* oxidation test) will be evaluated to determine if the concentrations of VOCs are high enough to assume that a change in concentration can be demonstrated. Based on initial calculations, the concentration of VOCs must be greater than 50 µg/L.

Field work for the *in situ* oxidation demonstration will take approximately 17 weeks. Prior to injection of oxidants into the aquifer, a capture zone will be established around the A zone extraction well and A zone piezometers by measuring water levels in the extraction well and nearby piezometers and monitoring wells. Once hydraulic capture is observed, groundwater samples will be collected at the extraction well and three piezometers to measure activity indicators including residual peroxide, dissolved oxygen (DO), oxidation reduction potential (ORP), temperature, pH, and conductance. In addition, samples will be collected and shipped to an off-site laboratory for analysis of total carbonates and TOC. Groundwater samples collected for VOC analysis during site characterization will be used for baseline VOC concentrations if these samples were obtained within one (1) month of the initiation of field tests.

5.3 SYSTEM OPERATION

In Situ Oxidation Field Work

The hydrogen peroxide will be injected into the aquifer at a rate of approximately 500 gallons in one-half to one hour per day. The final injection and extraction rates are dependent on the actual site hydrogeological conditions. Following the aquifer testing, calculations will be performed as part of the aquifer modeling to ensure that all of the injected material will be captured by the extraction system and that hydrogen peroxide injection rates are adequate to meet the project objectives. Additionally, the native concentration of ferrous ion within the groundwater will be measured to ensure that its concentration is sufficient to catalyze the Fenton's reagent process. Hydrogen peroxide will catalyze into Fenton's reagent in the presence of the ferrous ion, which is expected to be naturally occurring within the aquifer. Previous studies of natural attenuation in Northern Operable Unit C have demonstrated that the concentrations of ferrous iron in the groundwater at McClellan AFB should be sufficient to promote the Fenton's reagent process without the addition of an iron salt catalyst to the peroxide solution (Chapman, 1999). If the amount of iron diminishes and additional iron is needed, low concentrations of ferrous ions will be used to catalyze hydrogen peroxide into Fenton's Reagent prior to injection into the aquifer.

Previous studies of *in situ* oxidation indicate that this treatment is most effective in systems with a pH of 3 to 5. However, the pH of the aquifer will not be adjusted because the potential is too great that adverse chemical reactions will occur such as the release of metal species. Although the Fenton's reagent process does not produce hydroxyl radicals as efficiently under conditions of a higher pH, the reaction does occur (TerraVac, 1995).

The hydrogen peroxide will be injected in small but frequent pulses (500 gallons, once daily into each A zone piezometer) to minimize hydraulic dilution and hydraulic mounding. Air sparging will be used to help mix and spread the oxidant throughout the subsurface. Air sparging may also affect concentrations of VOCs. Therefore, the results of the *in situ* oxidation test will be compared to results from another treatability test performed in OU A at McClellan AFB in which air sparging was performed in addition to the injection of propane. The air sparging done at the OU A treatability site was continuous rather than intermediate and the test was performed for a longer period of time. However, the results will be interpolated to determine the amount of effect that air sparging will have on the *in situ* oxidation test area.

By collecting and analyzing samples prior to, during, and after oxidant injection, changes in residual peroxide, dissolved oxygen, and VOC concentrations in the groundwater will be analyzed to assess the effectiveness of *in situ* oxidation at this and similar sites across McClellan AFB. A detailed timeline of these activities follows:

Week 1: During this week, extraction will begin and pre-injection activity indicator sampling will be performed to determine baseline aquifer conditions. Baseline VOC sampling performed as part of the aquifer testing will be used as the baseline concentration data for the *in situ* oxidation study if these samples were obtained within one (1) month of week 1.

Weeks 2 – 5: Oxidant injection begins. During each round of injection, approximately 500 gallons of 10% strength hydrogen peroxide (with ferrous ion catalyst if needed) will be injected into each of the three A zone piezometers installed in the test area, followed by one hour of air sparging. One round of injection will be conducted every day, 5 days a week for approximately 4 weeks.

Hydrogen peroxide will be transported to the site in a tanker truck that is in compliance with state, federal, and base regulations. It will be stored at the site in three double-contained tanks, one located at each piezometer. Each piezometer will be constructed with at least 6 inches of exposed pipe at the wellhead to allow a threaded fitting with pressure gauge to be attached to the piezometer. Oxidant will be pumped from the truck or tank using a pneumatic pump that operates on peristaltic principles.

Using an oil free, environmental grade air compressor, 30 cubic feet per minute (cfm) of air will be pumped at 5 to 15 pounds per square inch (psi) into the groundwater at each piezometer for one hour after each round of oxidant injection. This is done to promote mixing and spreading of the oxidant in the subsurface.

Weeks 6 – 7: When activity indicators are detected at the extraction well, then the extraction pump from the well will be shut down for a period of two weeks to allow A zone water levels to return to pre-extraction levels. Activity indicators are changes in concentrations of residual peroxide (one to ten ppm); ORP (indicating a trend to oxidizing conditions); DO (increasing due to oxygen generated by breakdown of hydrogen peroxide); rising temperature, pH change, and conductivity.

Weeks 8 – 17: After the 2-week recharge period, the extraction well will be restarted and concentrations of VOC and activity indicator measurements in the extracted well and piezometer groundwater will be monitored during weeks 8, 10, 13, and 17.

All analytical data will be compared and evaluated to assess the effectiveness of oxidant injection at reducing the VOC concentrations in groundwater beneath the test area (see also Section 7.0). The half-

life of hydrogen peroxide is very short – on the order of hours to days. Therefore, it is not anticipated that any peroxide will remain in the aquifer since it completely dissolves into oxygen and water. This will be confirmed using the data collected throughout the field effort.

5.4 MATERIAL STORAGE

Materials to be used or generated during the field investigation and which require storage include sampling devices, wastewater, soil cuttings, personal protective equipment (PPE), hydrogen peroxide, and other solid waste from sampling activities. This section describes material storage, and Section 5.5 describes the management and disposal of these wastes.

5.4.1 Wastewater

Untreated groundwater will be generated during the drilling of soil borings, installation of monitoring wells, and during aquifer testing. Wastewater will be collected in 25,000-gallon water storage tanks prior to disposal (see Section 5.5.1).

5.4.2 Soil Cuttings

Soil cuttings generated during drilling activities will be stored in 20-cubic yard roll-off bins supplied by an on-site contractor. The on-site contractor will also manage the storage of the bins.

5.4.3 Hydrogen Peroxide

Approximately 1,500 gallons of a 10%hydrogen peroxide solution will be stored at the test site during the *in situ* oxidation test.

5.5 RESIDUALS MANAGEMENT

This subsection describes the management of wastes generated during the field investigation. Representative samples of each type of waste (*e.g.*, wastewater and soil) will be collected and analyzed as appropriate for disposal. Wastes that will be generated include:

- Water (groundwater and decontamination fluids);
- Soil;
- Used PPE; and
- Other solid waste from sampling activities.

5.5.1 Wastewater

Contaminated groundwater generated during this field effort will be collected in 25,000-gallon water storage tanks or other containers provided by McClellan AFB and discharged into the McClellan AFB GWTP or designated location for treatment and disposal in accordance with SOP No. McAFB-013 (Radian International, 1999c). Decontamination liquids will be transported to a designated location for treatment and disposal in accordance with SOP No. McAFB-013 (Radian International, 1999c).

5.5.2 Soil Cuttings

Soil cuttings generated during drilling activities will be collected in 20-cubic yard roll-off bins supplied by an on-site contractor. The waste will be labeled, tested, classified, and transferred by a McClellan AFB contractor to the contaminated soils holding area. Proper management and disposal of cuttings is determined after subsequent sampling and analysis of cuttings conducted in accordance with the *Soils Management Manual, Version 1.0* (McClellan AFB EMR, 1993).

5.5.3 PPE and Other Solid Waste from Sampling Activities

Items such as PPE, gloves, towels, rags, etc. that are used during sampling activities will be packaged for pick-up by a McClellan AFB contractor in compliance with Section 2.3.1 of the *Hazardous Waste Management Plan* (SM-ALC McAFB Instruction 32-2, 1996).

5.5.4 Hydrogen Peroxide Waste from *In Situ* Oxidation Activities

It is anticipated that no residual hydrogen peroxide will be generated during the *in situ* oxidation demonstration because only the exact quantity required for injection will be delivered to the site. However, any additional 10% hydrogen peroxide solution will be stored in 50-gallon polymer drums and transported off the base by the vendor or transferred to an appropriate base facility for treatment of disposal in compliance with the *Hazardous Waste Management Plan* (SM-ALC McAFB Instruction 32-2, 1996).

5.6 DEMOBILIZATION AND SITE RESTORATION

Subsequent to completion of all field activities, site demobilization will occur. Rented equipment, including fences, tanks, compressors, and pumps, will be cleaned and returned. All other contractor owned equipment will be cleaned and removed from the site. Equipment decontamination and site restoration will follow procedures presented in the McClellan AFB QAPP SOP No. McAFB-004, Tables 10, 11, and 12 (Radian International, 1999c). All tanks, hoses, fencing used by vendors for the *in situ* oxidation test will be removed. Any additional hydrogen peroxide solution will handled in accordance with Section 5.5.4. All garbage will be disposed of in waste bins designated for use by the base.

6.0 PERMITTING AND REGULATORY COMPLIANCE

This section describes all applicable or relevant regulatory requirements related to the activities discussed in Section 5.0. These requirements include the acquisition of permits and compliance to regulations. The necessary permitting and compliance issues are described below.

6.1 REQUIRED PERMITS

All operations will comply with all applicable federal, state, and local regulations for which permits normally would be required. Operations subject to such regulations are discussed below.

6.1.1 Site/Activity Clearances

The field coordinator will meet with the McClellan AFB field project manager to obtain the necessary permits or clearances for each boring or sampling location before field activities begin. The field coordinator also arranges for coordination with base personnel if field activities will disrupt McClellan AFB or its tentant's normal working environment. The McClellan AFB field project manager coordinates with appropriate entities to issue site clearances and verify that underground utilities or other buried obstacles will not be encountered. Additional guidance can be found in the General Field Operations SOP, McAFB-042 (Radian International, 1999c).

6.1.2 Disposal of Soil Cuttings

Soil cuttings generated during drilling activities will be stored in bins supplied by an on-site McClellan AFB contractor. The on-site contractor also performs any necessary manifesting and manages the storage and disposal of the soil cuttings according to the requirements of the McClellan AFB Soils Management Plan (McClellan AFB EMR, 1993). No additional permits will be required.

6.1.3 Wastewater Discharge

Wastewater generated from the field tests will be sent to existing McClellan AFB treatment facilities for treatment prior to discharge. No additional permits will be required.

6.1.4 Hazardous Waste Storage

This section discusses the storage and disposition of hazardous materials and wastes during the demonstration. The hazardous material hydrogen peroxide is used for the *in situ* oxidation demonstration. A 10% strength hydrogen peroxide solution for injection will be stored on-site. The concerns associated with the storage of hydrogen peroxide are that if a leak develops in the tank, peroxide may liberate oxygen and promote combustion of flammable materials. To prevent this potential concern, the hydrogen peroxide will be stored inside dual contained tanks. McClellan AFB Environmental Management staffwill be notified of the intent to store the hydrogen peroxide on site during the demonstration according to established base procedures. At the end of the demonstration, any leftover hydrogen peroxide will be returned to the supplier or transferred to McClellan AFB for disposal as a hazardous waste.

There are many specific requirements regarding the storage and use of hazardous materials on McClellan AFB. Among these requirements are:

- Updating the list of hazardous materials identified in the "Certification Regarding Identification of Hazardous Materials in the Performance of On-base Services" (Certification).

- Updating or providing additional MSDS for each item on the Certification list.

- Submit a "Certification Regarding Identification of Hazardous Materials in the Performance of On-Base Services" and "Memorandum for Hazardous Material Support Center" to the McClellan AFB Hazardous Material Support Center 15 days prior to bringing any hazardous materials identified in FAR 52.223-3 onto McClellan AFB.

- Update the Report monthly until the hazardous material is removed from McClellan AFB.

- Affixing a hazardous material warning label to all such materials.

- Conduct and document employee hazard communication training before beginning the work at McClellan AFB.

6.1.5 Injection

Because this project is being conducted as a treatability study under CERCLA, it is exempt from any injection permit requirements for the *in situ* oxidation test. Field operations will be conducted to meet the substantive intent of the appropriate injection permit requirements. Field activities during the *in situ* oxidation test will be conducted to ensure that 100% of the injected hydrogen peroxide is removed or degraded within the aquifer. In that, the hydrogen peroxide will only be injected within the capture zones of groundwater extraction wells.

6.2 REGULATORY COMPLIANCE

In addition to fulfilling the requirements in Section 6.1, the implementation and operation of the technology demonstration must comply with other federal, state, and local regulations. Key regulatory agencies include the Department of Toxic Substance Control (DTSC), the Central Valley Regional Water Quality Control Board (CVRWQCB), and the U.S. Environmental Protection Agency (U.S. EPA).

This section describes all applicable or relevant regulatory requirements related to the activities discussed in Section 5.0. These requirements include the acquisition of permits and the compliance to regulations. The necessary permitting and compliance issues include, but are not limited to:

- CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan, requires the implementation of a remedial solution that provides short and long-term effectiveness and permanence, reducing toxicity, mobility, or volume through treatment in a cost effective manner acceptable to federal, state, local personnel, and the local community.

- Resource Conservation and Recovery Act (RCRA) as amended, 42 United States Code (USC) 901 et. seq. and Title 22 of CCR. It is possible that treatment systems required for full-scale implementation of the aggressive remediation strategy may generate RCRA hazardous waste (*e.g.*, VOC-laden activated carbon). The specific RCRA wastes to be generated would vary from site-to-site due to local regulations and, therefore, must be considered individually for each site.

- Clean Water Act (CWA). The CWA requires compliance with the applicable requirements of discharge permit issued to the facility by the county. Wastewater generated will be treated by an existing system; therefore, there are no specific compliance issues associated with this dewatering at McClellan AFB. Each site implementing the aggressive remediation strategy will be required to evaluate specific National Point-Source Discharge Elimination System (NPDES) or other discharge permit requirements for treated groundwater.

- Safe Drinking Water Act (SDWA) as amended, 42 USC 3300f et. seq. SDWA is not applicable since the aggressive remediation strategy surface water discharge will be treated prior to discharge.

- Clean Air Act (CAA) as amended, Title 42 USC 3401 et. seq. Limits the emission of both "criteria" (ozone and its precursors oxides of nitrogen and reactive organic compounds, as well as sulfur dioxide and particulate matter less that 2.5 microns in diameter) and "non-criteria" or hazardous air pollutants. Because no soil gas will be extracted during the demonstration, the CAA does not apply. However, if the aggressive remediation strategy using aggressive dewatering and SVE is implemented at full-scale, some type of air emissions control technology may be required depending on local CAA implementation requirements.

- Toxic Substances Control Act (TSCA). Because TSCA regulated materials (a 10% hydrogen peroxide solution) will be stored on site, TSCA regulation 40 CFR 710 is applicable.

- Mixed Waste Regulations. These regulations are not applicable because the technologies are not designed to treat mixed wastes (*e.g.*, RCRA wastes mixed with radioactive wastes).

- Federal Insecticide, Fungicide, Rodenticide Act (FIFRA). The majority of FIFRA regulated wastes are classified as either semi- or non-VOCs, and subsequently not particularly amenable to treatment by the aggressive remediation strategy. However, depending on the specific contaminant, it is possible that these technologies may be used at a FIFRA-regulated site.

- Occupational Safety and Health Act (OSHA). Since McClellan AFB is a federal site, the implementation of this project is governed by federal OSHA regulations. This requires the preparation of a site-specific health and safety plan for all work to be conducted on the site. Workers also need to be informed of the nature of the hazards present on the site. All equipment used on the site will comply with OSHA safety regulations. Since McClellan AFB is in California, the implementation of this project will also substantively comply with the regulations contained in Title 8 of California/OSHA. In case of conflicts between federal and California OSHA requirements, the more stringent regulation will be applied.

- State and Local Regulations. The concerned state and local regulatory agencies include, but are not limited to, the Sacramento Metropolitan Air Quality and Management District (SMAQMD), the State of California Central Valley Regional Water Quality Control Board (CVRWQCB), and the State of California Department of Toxic Substance Control (DTSC). No permits are required from these agencies for the demonstration of the aggressive remediation strategy at McClellan AFB; however, recognizing that all sites have unique

characteristics, each potential full-scale application of the technology would need to comply with all applicable state and local regulations promulgated by these agencies.

7.0 SAMPLING PLAN

Comprehensive and accurate evaluations of the aggressive remediation strategy depends on obtaining a complete, representative, and consistent data set chronicling the results of the project. The data must characterize the contaminant concentrations and properties that influence contaminant transport. The project sampling plan specifies the sampling locations, types of samples, and procedures for collecting, packaging, and shipping samples.

The goals of this sampling plan are to ensure that all information, data, and resulting interpretations are scientifically-defensible, technically sound, valid, and properly documented. The implementation of procedures may change depending on the actual field conditions encountered during field work. If changes to the groundwater sampling procedures are required, McClellan AFB will be notified and approve of any potential changes required by field conditions.

Sampling activities to support this project include two phases: (1) site characterization sampling, and (2) technology performance sampling for the *in situ* oxidation test.

7.1 SITE CHARACTERIZATION SAMPLING

Site characterization sampling is required to refine the site conceptual model to allow for a successful completion of this project.

7.1.1 Sampling Objectives and Rationale

The sampling objectives for the site characterization are to:

- Obtain total organic carbon (TOC) and dry bulk density data for aquifer solids for use in groundwater flow and vadose zone models.

- Obtain a quality data set of VOC concentrations to assure that COCs in the A, B, and C zones at the test site may be delineated, quantified, and the mass of VOC contamination may be calculated. The mass of VOC contamination must be determined for calculations in groundwater and soil vapor models.

- Obtain hydrogeologic data to support fate and transport modeling and to support process parameter selection for the *in situ* oxidation test.

7.1.2 Sampling Details

During drilling activities, soil samples will be collected at approximately 10 feet above and 10 feet below the groundwater table (approximately 95 feet bgs) as well as at depths corresponding to the A, B, and C monitoring zones and analyzed for TOC and bulk density. Therefore, a total of 20 soil samples will be collected; four from each boring (Table 7-1).

After all piezometers and extraction wells are installed and developed, as stated in Section 5.0, ground-water samples will be collected from each well and piezometer. Therefore, a total of 11 groundwater

Table 7-1. Soil Sampling and Analysis Matrix Table

Soil Boring	Approximate Depth (feet bgs)	Sampling Method
WIPSB01	95	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	115	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	170	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	240	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
WIPSB02	95	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	115	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	170	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	240	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
WIPSB03	95	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	115	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	170	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	240	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
WIPSB04	95	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	115	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	170	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	240	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
WIPSB05	95	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	115	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	170	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)
	240	D2937 (Bulk Density) U.S. EPA 415.1 (TOC)

bgs = below ground surface
TOC = total organic carbon

samples will be collected from the new locations – five samples from the A monitoring zone, three from the B monitoring zone, and three from the C monitoring zone. Figure 5-1 shows the proposed locations of

the piezometers and extraction wells. Additionally, groundwater samples will be collected from A, B, and C zone well clusters located upgradient, downgradient, and crossgradient of the test area. (The downgradient well cluster is comprised only of A and B zone wells; therefore, a C zone groundwater sample will be collected from MW-132 located approximately 90 feet south-southeast (see Figure 2-7). Table 7-2 presents the sampling and analysis matrix. All groundwater samples will be analyzed by EPA Method SW8260B.

Table 7-2. Groundwater Sampling and Analysis Matrix Table

Well Number[a]	Monitoring Zone	Sampling Method
EW A (WIPSB01)[a]	A	SW8260B[c] (VOCs)
EW B (WIPSB02)[a]	B	SW8260B[b] (VOCs)
PZ 1A (WIPSB03)[a]	A	SW8260B[c] (VOCs)
PZ 1B (WIPSB03)[a]	B	SW8260B (VOCs)
PZ 1C (WIPSB03)[a]	C	SW8260B[c] (VOCs)
PZ 2A (WIPSB04)[a]	A	SW8260B[b] (VOCs)
PZ 2B (WIPSB04)[a]	B	SW8260B (VOCs)
PZ 2C (WIPSB04)[a]	C	SW8260B (VOCs)
PZ 3A (WIPSB05)[a]	A	SW8260B (VOCs)
PZ 3B (WIPSB05)[a]	B	SW8260B[c] (VOCs)
PZ 3C (WIPSB05)[a]	C	SW8260B (VOCs)
MW-164	A	SW8260B (VOCs)
MW-165	B	SW8260B (VOCs)
MW-166	C	SW8260B (VOCs)
PZ-497	A	SW8260B (VOCs)
PZ-498	B	SW8260B (VOCs)
PZ-499	C	SW8260B (VOCs)
PZ-130	A	SW8260B (VOCs)
PZ-131	B	SW8260B (VOCs)
MW-132	C	SW8260B (VOCs)

[a] Well names will be changed based on McClellan AFB naming protocol.
[b] Field duplicate samples will be collected in addition to normal samples for these wells.
[c] Ambient blank samples will be collected in addition to normal samples at these locations.
[d] Equipment blank samples will be collected prior to collecting normal samples at these locations.

EW = extraction well
PZ = piezometer
VOC = volatile organic compound

7.2 TECHNOLOGY PERFORMANCE SAMPLING

This section presents the objectives, rationale, and details for sampling during *in situ* oxidation field work.

7.2.1 Objectives

The objective of the sampling that will be performed during *in situ* oxidation field work is to characterize the performance of the technology using VOC concentrations and activity indicator levels in

groundwater. These data will provide the information required to determine if *in situ* oxidation is an effective tool for more quickly and cost effectively reducing VOC concentrations at the test area.

7.2.2 Sampling Details

Table 7-3 presents the sample schedule for the *in situ* oxidation test.

Table 7-3. *In Situ* Oxidation Sampling Matrix

Sample/Measurement (Method)	Number of Samples/Measurements				
	Within 1 month of initiating *in situ* oxidation test[a]	Week 1	Weeks 2–5	Weeks 6–7	Weeks 8–17
Residual Peroxide, DO, ORP, pH, Temperature, Conductance from A Zone Extraction Well	0	1	20	0	8
Residual Peroxide, DO, ORP, pH, Temperature, Conductance from 3 A Zone Injection Wells	0	3	0	0	0
TOC (SW9060), TSS (E160.2), and Total Carbonate (E310.1) from A Zone Extraction Well	0	1	0	0	0
TOC (SW9060), TSS (E160.2), and Total Carbonate (E310.1) from 3 A Zone Injection Wells	0	3	0	0	0
VOCs (SW8260B) from A Zone Extraction Well	1	1	4	1	5
VOCs (SW8260B) from 3 A Zone Injection Wells	3	0	6	3	3

[a] These samples will be collected as part of the site characterization of the study area or the groundwater monitoring program.

DO = dissolved oxygen
ORP = oxidation reduction potential
TOC = total organic carbon
TSS = total suspended solids
VOCs = volatile organic compounds

VOC Sampling

The groundwater samples collected and analyzed for VOCs during the site characterization field activities will provide the baseline concentration for the *in situ* oxidation study.

One groundwater sample will be collected from the A zone extraction well during week 1 and analyzed by Method SW8260B for VOCs. During weeks 2 through 5, a total of 10 groundwater samples will be collected from the A zone extraction well and piezometer/injection wells and analyzed by Method

SW8260B for VOCs. During weeks 6 and 7, four groundwater samples will be collected, and during weeks 8 through 17, eight groundwater samples will be collected all from the extraction well and three A zone piezometers and analyzed by Method SW8260B for VOCs (Table 7-3).

All groundwater sampling and analysis will be performed in accordance with procedures specified in the basewide QAPP (Radian International, 1999c).

Activity Indicator Sampling

During week 1 of field activities, field measurements for the following activity indicators will be collected at the extraction well and three A zone piezometers:

- Residual peroxide using a colorimetric test strip.
- ORP using a portable ORP meter.
- DO using a portable DO meter.
- Temperature, pH, and conductance using field instruments that measure these parameters.

In addition, during week 1, groundwater samples will be collected from the extraction well and piezometers and sent to an off-site laboratory for analysis of TOC by U.S. EPA Method SW9060, total carbonate by Method E310.1, and total suspended solids (TSS) by Method E160.2.

During weeks 2 through 5, the previously described activity indicator levels measured with field instruments will be collected at the extraction well at the end of each day of injection, five days a week. After the extraction well is restarted during weeks 8 through 17, these same activity indicator field measurements will be collected at the same time groundwater samples are collected for VOC analysis (eight times).

Temperature, pH, and conductance measurements will be collected in accordance with the basewide QAPP (Radian International, 1999c). Peroxide, ORP, and DO measurements will be taken according to procedures provided in Appendix C.

7.2.3 *In Situ* Oxidation Sampling Rationale

This section presents the rationale for collecting the field measurements and groundwater samples described in Section 7.2.2.

Activity Indicator Sampling

Residual peroxide, DO, ORP, pH, temperature, and conductance are used to monitor in the field oxidation that may or may not be occurring in the groundwater beneath the site. These measurements are collected during the pre-injection phase to establish baseline conditions. After injection starts, these field measurements are taken on a daily basis to monitor and adjust the injection schedule and amount as appropriate. During the post-injection sampling phase, these measurements provide a final picture of the oxidation that may still be occurring. Residual peroxide is measured to ensure that adequate doses of the oxidant are introduced into the groundwater.

Geochemistry of the subsurface can affect implementation of this technology. Therefore, during the pre-injection phase, groundwater samples will also be analyzed for TOC, TSS, and total carbonate. The levels of these geochemical parameters are used to determine the dose of hydrogen peroxide used.

VOC Sampling

Groundwater samples will be analyzed for VOCs throughout the implementation of this project, as noted in Table 7-3. The removal rate of VOCs varies throughout the *in situ* oxidation procedure and is a function of the various volumes of peroxide, TCE, and other geochemical parameters in the aquifer. The removal rate is also a function of fate and transport (*e.g.* permeability, gradient, pumping rates and the distance between the extraction well and the injection points). During the *in situ* oxidation test, a decreasing trend of TCE concentrations is first anticipated followed by an increasing trend in TCE concentrations. The initial decrease in TCE concentrations occurs as the peroxide reacts with the VOCs. After the peroxide injection is stopped and the peroxide concentrations decrease (due to degradation, chemical reactions with VOCs and other constituents in the aquifer, and extraction along with the pumped groundwater), concentrations of VOCs begin to increase as they are replenished from upgradient sources.

Therefore, groundwater samples will be collected in greater numbers and frequency in the beginning of the test and then with decreasing frequency as the test progresses. Groundwater samples will be collected from the extraction well and surrounding injection wells as shown in Table 7-3. A total of 23 groundwater samples for VOC analyses will be collected.

A statistical analysis of these analytical results will be prepared as part of the TAAR (see Section 4.6).

The sampling and data collection proposed for this *in situ* oxidation study will provide information and results to perform a mass balance calculation to determine the utilization rate of the injected peroxide. In order to validate the cost and performance of this technology, the optimum dose will be determined. The volume of the soil formation in the zone of influence and the corresponding water volume will be estimated based on the radial distance between the extraction well and the injection points and lithologic data. The total mass of VOCs that will react with oxidant within the zone of influence will be estimated based on known concentration data. Lastly, the total mass of peroxide to be used in the injection process will be estimated based on stoichiometric ratios. The half-life of hydrogen peroxide is very short – on the order of hours to days. Therefore, it is not anticipated that any peroxide will remain in the aquifer since it completely dissociates into oxygen and water. This will be confirmed using the data collected throughout the field effort.

During the oxidation process, microbial activity will be temporarily eliminated in the subsurface test area. This is a reversible condition and once the injection stops, the subsurface will begin to return to its original state.

7.3 FIELD METHODS AND PROCEDURES

This section describes the field methods and procedures that will be used for groundwater sampling during all phases of this project. Field methods and procedures are provided for sample collection, sample preservation, packaging, shipment, and equipment decontamination. Sample labeling and chain-of-custody procedures are described in Section 8.7.3. The primary references for the field methods and procedures in Section 4.3.1 of the *Sampling and Analysis Plan, Groundwater Treatment Facilities,*

McClellan AFB, CA (OHM, 1997) and SOP No. McAFB-013 of the basewide QAPP (Radian International, 1999c). Sample custody and documentation will follow Section 6.0 of the basewide QAPP (Radian International, 1999c).

7.3.1 Sample Containers

Whenever applicable, the analytical testing laboratory will provide clean containers and appropriate container lids with Teflon® or aluminum liners for sample collection. Labels will be firmly attached to the side of the sample container (not the lid). The following information will be legibly and indelibly written on the label:

- Facility name;
- Sample identification;
- Sampling date;
- Sampling time;
- Sample collector's initials;
- Preservatives used;
- Type of sample; and
- Analysis to be performed.

Sample containers shall be specific to the analysis to be performed on the sample. Refer to Section 8.0 and Table 5-1 of the basewide QAPP (Radian International, 1999c) for additional information on appropriate sample containers.

7.3.2 Sample Preservation

Water samples will be properly prepared for transportation to the laboratory under refrigeration and chemical preservation. Sample containers provided by the laboratory will have any necessary chemical preservatives added to the containers prior to being sealed and shipped. While in the field, all collected samples must be placed in ice-filled chests or equivalent containers. Refer to Table 7-4 of this WIP and Table 5-1 of the basewide QAPP (Radian International, 1999c) for details on sample holding times, acceptable preservations for sample type, and the analysis to be performed.

7.3.3 Sample Packaging and Shipment

The following packaging and labeling requirements for the sample materials are appropriate for shipping the sample to the testing laboratory:

- Preserve samples with ice and cool to 4°C;
- Package sample so it does not leak, spill, or vaporize;

Table 7-4. Sample Storage and Preservation Requirements

Parameter	Method	Holding Time	Container	Preservation	Storage Requirements
Purgeable Organic Compounds	SW8260B	14 days	Three 40-mL glass vials with Teflon® liners	pH <2 with HCl	4°C
Total Organic Carbon	SW9060/ E415.1	28 days	500 mL polyethylene bottle (w); 4-oz widemouth glass jar (s)	pH <2 with HCl or H_2SO_4 (w)	4°C
Total Suspended Solids	E160.1	7 days	One 500-mL polyethene bottle	None	4°C
Alkalinity/Total Carbonate	E310.1	14 days	500 mL polyethylene bottle (w)	None	4°C
Bulk Density	D2937	*	One sleeve	*	*

(w) = water samples
(s) = soil samples
mL = milliliter
HCl = hydrochloric acid
H_2SO_4 = sulfuric acid
°C = degrees Celsius
mL = milliliters

* Bulk density samples are sent to a laboratory for geophysical analysis; therefore, no specific holding time or preservation is required and there is no storage requirements.

- Describe sample media and contaminant on each sample label;
- Label cooler with sampler's name, address, and telephone number;
- Label cooler or equivalent with laboratory's name, address, and telephone number;
- List the quantity of samples;
- Date of shipment;
- Attach chain-of-custody forms inside shipment container; and
- Attach and initial tamper seal on the outside of cooler.

Additional details for sample packaging and shipping are documented in Section 8.0 of this WIP and Section 6.0 of the basewide QAPP (Radian International, 1999c).

7.3.4 Equipment Assembly, Check, and Calibration

Prior to the sampling event, all equipment to be used will be assembled and its operating condition verified, calibrated (if required), and properly cleaned (if required). In addition, all recordkeeping materials will be prepared according to SOP No. McAFB-013 (Radian International, 1999c). Arrangements for repairs or replacements are made for any inoperative equipment.

Prior to field use, where appropriate, equipment will be calibrated according to the manufacturer's specifications and SOP No. McAFB-024 (Radian International, 1999c). This applies to the equipment for making on-site measurements of pH, ORP, specific conductance, dissolved oxygen, and water temperature.

7.3.5 Groundwater Sampling Procedures

Groundwater samples will be collected by filling the containers (three 40-mL VOA vials per sample) to a positive meniscus and tightly closing the container lids. Special care will be taken to minimize the agitation and aeration of samples during sample collection. This will minimize the potential for volatilization of VOCs from the water during sampling activities. Samples will be preserved with hydrochloric acid (HCl) or equivalent and stored at 4°C for shipment to laboratory in accordance with the Basewide QAPP (Radian International, 1999c).

Special care will be exercised to prevent contamination of the groundwater and extracted samples during the sampling activities. The two primary ways in which such contamination can occur are through improper handling of a sample or through cross-contamination of the groundwater by improper cleaning of equipment between wells sampled.

To prevent such contamination, all sampling equipment will be thoroughly cleaned before and between use at different sampling locations in accordance with SOP No. McAFB-013 (Radian International, 1999c). In addition, further precautions will be followed including wearing new disposable latex (or similar) gloves each time a different well is sampled.

7.3.6 On-Site Parameter Measurement

The following measurements will be taken using calibrated field equipment. These parameters will be measured for each groundwater sample collected during the field investigation:

- Dissolved oxygen;
- Oxidation reduction potential;
- pH;
- Specific conductance; and
- Temperature.

These parameters will be measured in unfiltered, unpreserved, "fresh" water samples collected by the same technique as the samples collected for laboratory analyses. Testing for peroxide concentrations will be performed as specified in Appendix C. All on-site measurements will follow manufacturers specifications and the procedures outlined in SOP No. McAFB-024 (Radian International, 1999c). The measured values will be recorded in the field logbook.

7.3.7 Equipment Decontamination

All sampling and test equipment that contacts the interior well casing will be thoroughly cleaned prior to use in the field. This includes water level tapes or probes, pumps, tubing, bailers, lifting line, test equipment for on-site use, and other equipment or portions thereof which are to be immersed. The cleaning process is as follows:

- Clean with tap water and phosphate-free laboratory grade detergent using a brush, if necessary;
- Rinse thoroughly with tap water; and
- Rinse thoroughly with distilled water.

After sampling a well, the equipment used should be cleaned with phosphate-free laboratory grade detergent and rinsed thoroughly with distilled water, methanol, and hexane or cyclohexane. No metals contamination is anticipated; however, the decontamination protocol will be modified to include a 0.1 Normal (N) nitric acid rinse if it is determined that metals analysis needs to be included in the sampling plan.

Any necessary deviation from these procedures will be documented in the permanent record of the sampling episode.

7.3.8 Sample Documentation

After samples have been obtained, chain-of-custody procedures will be followed to establish a written record concerning sample movement between the sampling site and the testing laboratory. Each shipping container will have a chain-of-custody form completed by the site sampling personnel packing the samples. The chain-of-custody form for each container will be completed in triplicate. One copy of this form will be maintained at the site, and the other two copies will be sealed in the container with the samples. One of the laboratory copies will become a part of the permanent record for the sample to be returned with the sample analyses.

7.4 QUALITY CONTROL SAMPLING

A detailed description of the quality assurance (QA) program is presented in Section 8.0 of this WIP. A minimum of 10% of VOC samples collected during the field investigation will be collected in duplicate and submitted for analysis. One field duplicate sample will be taken during the week 2-5 sampling and two field duplicate samples will be taken during weeks 8-17.

Performance evaluation samples will also be submitted to the laboratory as described in Section 8.0 and in Section 11.2 of the basewide QAPP (Radian International, 1999c). One performance evaluation sample will be submitted double blind to the laboratory prior to week 6.

8.0 QUALITY ASSURANCE PROJECT PLAN

All quality assurance/quality control (QA/QC) procedures used for this demonstration project comply with the requirements of the *Basewide RI/FS QAPP* (Radian International, 1999c). The project-specific QAPP presented in this section is a supplement to, not replacement for, the basewide QAPP. Procedures from the basewide QAPP should be the reference for all work on this project as supplemented by this section.

8.1 PROJECT OBJECTIVES

The overall project goal is to develop and assess an aggressive remediation strategy that offers a substantial reduction in the life cycle cost of remediating VOCs in groundwater at this site and other applicable sites at McClellan AFB. The data that need to be collected to accomplish the goal for this project are discussed below.

In addition to the objectives necessary for obtaining results on the specific technologies that comprise the aggressive remediation strategy presented below, data for a cost analysis will be collected. The life cycle costs of the aggressive remediation strategy (*i.e.,* aggressive dewatering with SVE and *in situ* oxidation) will be compared to the costs of conventional groundwater extraction and treatment. Quality cost-related data from conventional groundwater extraction and treatment and dual-phase extraction in use at McClellan AFB must be collected from Environmental Management (EM) at McClellan AFB. These costs will include, but are not limited to, material storage, waste storage and/or transfer and treatment, utilities and capital costs for materials.

To accomplish the overall project goal, individual project objectives have been established for each portion of this test. Data quality objectives (DQOs) specify the type, quality, quantity, and uses of data required to reach the project goal. Figure 8-1 illustrates the DQO process; the figure is adapted from the *Guidance for the Data Quality Objectives Process* (Environmental Protection Agency, 1994). The primary and secondary objectives as well as the DQOs for the aggressive remediation strategy are presented below.

Primary Objective 1 – Collect site-specific data to support aggressive dewatering with SVE and *in situ* oxidation evaluations.

> To facilitate modeling and *in situ* oxidation, soil samples will be collected and analyzed for TOC by EPA method 415.1 and for bulk density by ASTM method D2937. Groundwater levels will be measured in monitoring wells within, upgradient of, downgradient of, and crossgradient to the test area. Aquifer tests will be conducted to determine hydrogeologic conditions within the test area. The test and sampling strategy presented in Sections 5.0 and 7.0 will be used. The Basewide QAPP (Radian, 1999) contains DQOs for these measurements.

Primary Objective 2 – Evaluate if the aggressive dewatering with SVE is economically feasible.

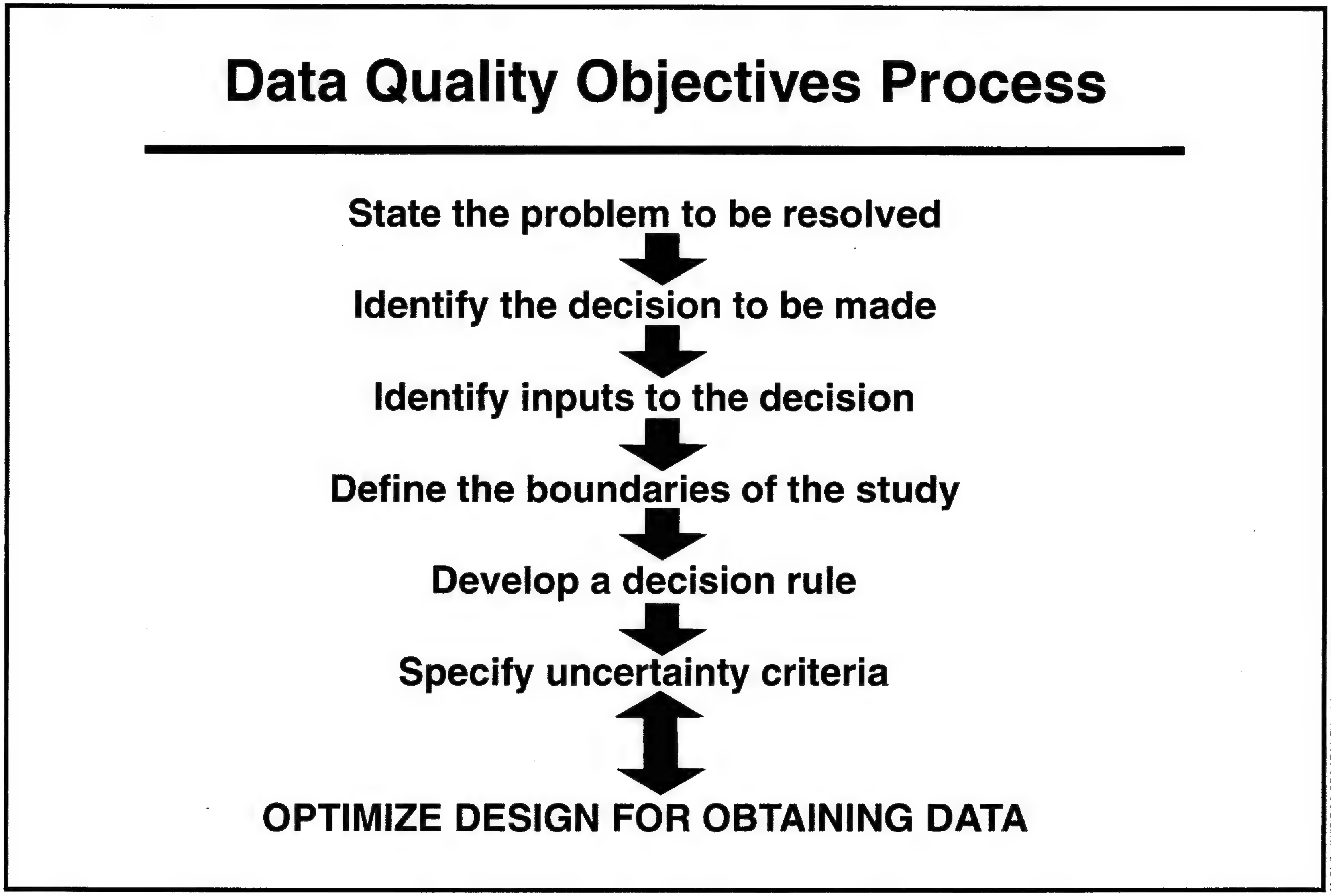

Figure 8-1. Data Quality Objectives Process

This project goal will be accomplished by employing a numerical groundwater model and an analytical SVE model developed with site-specific data. These models will be used to simulate the aggressive dewatering of the A monitoring zones in conjunction with SVE to assess if this strategy can cost effectively reduce the VOCs in the A monitoring zone. Groundwater modeling will simulate conditions of dewatering and a dewatered volume will be defined prior to the construction of the SVE model. Output from the models will be used in calculations to estimate groundwater volume pumped, soil gas removed, and VOC mass removed. With these and unit costs from other sources, the assessment will generate costs used to assess the life cycle costs of the technology. The costs to perform the aggressive dewatering and SVE can then be compared to the life cycle cost of more traditional pump and treat technologies.

Primary Goal 3 – Determine the percent removal of VOCs achieved for the *in situ* oxidation technology.

This project goal will be achieved by comparing treated and untreated concentrations of VOCs in groundwater during the test period at the 90% confidence level. The sampling strategy presented in Section 7.0 and Table 7-3 will be used. Groundwater samples will be analyzed for VOCs using EPA Method SW8260B.

Primary Goal 4 – Determine the cost effectiveness of the aggressive remediation strategy.

This goal will be achieved by determining the costs for full-scale implementation of the strategy. Cost data will be based upon data collected during field evaluations and those from the modeling performed. Standard engineering principles will be used to scale-up the costs, as required, to determine the costs for a full-scale system.

Secondary Goal 1 – Determine the concentrations of geochemical indicators that may affect the performance of the *in situ* oxidation test.

This goal will be achieved by measuring TOC, TSS, total carbonate, residual hydrogen peroxide, DO, ORP, pH, groundwater temperature, and conductance in groundwater extracted from wells during the test. TOC will be analyzed by EPA method SW9060; TSS by EPA method E160.2; total carbonate by method E310.1; residual hydrogen peroxide by field colormetric tests; and DO, ORP, pH, temperature, and conductance by field measurement devices. Table 7-3 and Section 7.0 detail the sampling strategy to be used.

Secondary Goal 2 – Document observed operating problems and their resolutions for the *in situ* oxidation test.

Process operating parameters will be monitored by field staff throughout the test.

Step 1: Problem Statement

An aggressive remediation strategy is being designed so that the life cycle cost of remediating VOCs in groundwater at this site and other applicable sites at McClellan AFB will be substantially reduced. Aggressive dewatering coupled with SVE technology is an innovative combination of technologies that is not common or proven. Few data are available to determine if the combination can substantially reduce the life cycle cost of remediating VOCs at McClellan AFB. *In situ* oxidation is an innovative technology that has been demonstrated to be useful in reducing the concentration of VOCs in groundwater at sites

other than McClellan AFB (please refer to Section 3.4.2). However, the time it takes to reduce the concentration of VOCs, the amount that the concentration of VOCs are reduced, and the logistics of performing the technology have not been demonstrated at McClellan AFB. A preliminary *in situ* oxidation test will be performed to assess the projected cost and performance to support the decision for implementing this technology as part of the aggressive remediation strategy.

Step 2: Decisions to be Made

If a 25% reduction in the life cycle cost and a reduction in the time to cleanup can be shown, the aggressive remediation strategy will be considered a promising technology. To overcome the lack of data on aggressive dewatering, groundwater and soil vapor models will be used to simulate the aggressive dewatering and SVE technology to assess if a full-scale treatability test is warranted. The modeling results will be used to assess the time and volumes of groundwater and gas removal in remediating VOCs in the A monitoring zone using the aggressive dewatering and SVE technologies. The site conceptual model that forms the basis for the groundwater and SVE models is outlined in Section 2.5 of this report. Based on the data presented in that section and the input data needed to perform the groundwater and SVE models listed in Tables 2-4 and 2-5, the following items need to be addressed in order to perform the modeling:

- The vertical communication and leakage from the B monitoring zone is or is not too great to allow dewatering of the A monitoring zone beneath the study area.
- The number, locations, and pumping rates of wells required for dewatering can be determined with limited uncertainty.
- The total VOC mass in the A zone volume of the aquifer and the adjoining vadose zone before any simulation or oxidant injection can be determined with limited uncertainty and for post-dewatering and SVE can be estimated with limited uncertainty from model simulation data.
- The number, locations, and extraction rates of SVE wells required for mass removal can be determined with limited uncertainty.

The *in situ* oxidation test will be used to assess the cost and performance of remediating VOCs in groundwater using this technology for use as part of the overall aggressive remediation strategy. The following items were identified as decisions that would need to be addressed in order to perform the technology.

- Quantify, to the extent practicable, the VOC contamination reduction as a result of the oxidant injection into the test area.
- Determine the cost to implement *in situ* oxidation at the site versus the mass of contaminants removed.

Step 3: Inputs to the Decisions

Inputs to the decisions are discussed below and are included in Tables 2-4, 2-5, and 7-3. Both the aggressive dewatering with SVE and the *in situ* oxidation technology will be evaluated for economic

and/or technological feasibility. If one is determined not to be feasible, the other may be used. All of the soil samples will be collected during the drilling of the boreholes that will be used to install the extraction wells and piezometers for this study. The first three decision items must be assessed prior to completing the construction of the groundwater model.

1. The amount of connection between the two aquifer zones will be assessed using three aquifer tests that pump the A and B aquifers separately and in unison while the effects to the A, B, and C monitoring zones are measured in local piezometers.

2. Aquifer parameters, hydraulic conductivity and storativity, for the A and B monitoring zones will be calculated from the data collected from two aquifer tests, one which pumps the A monitoring zone and one which pumps the B monitoring zone. These data will be used as input into the groundwater model to simulate the optimal placement and extraction rates for the number of extraction wells needed to dewater the area of interest. Other aquifer test data available from the base will be compared to the data collected during this study to determine if these aquifer parameters can be measured accurately enough to preclude aquifer tests at subsequent sites.

3. Groundwater samples will be collected from the newly installed piezometers and extraction wells and analyzed using method SW8260B for VOCs. These data and analytical data from the McClellan AFB GWMP will establish the baseline groundwater contamination levels in the test area. This will be the initial groundwater contamination input into the groundwater model. Groundwater contaminant data collected from neighboring wells as part of the groundwater sampling and analysis program (GSAP) will be utilized to illustrate contaminant trends in the area.

The groundwater model must be completed and the last two decisions for aggressive dewatering with SVE assessed prior to the completion of the SVE model.

4. Bulk density measurements will be analyzed from soil samples collected above and below the water table from five boreholes. Estimates of the amount of contaminant mass left as residual in the soil pore water will be converted into soil mass numbers to be used as the initial input into the SVE model. Bulk density measurements are highly variable between samples because of the heterogenous nature of soil samples. Enough bulk density measurements will need to be collected to estimate the range of bulk density measurements and the average bulk density of the material.

5. The total organic carbon (TOC) content will be measured from soil samples collected above and below the water table from five boreholes. These data will be used as input data into the SVE model. The TOC content of the soil is an important factor to estimate that amount of contaminant mass that is adsorbed onto the soil. The TOC data will be compared to historical data collected at the base to determine if these data need to be collected during subsequent aggressive remediation studies at other sites on the base.

Three injection wells (three A zone piezometers) and one A zone extraction well will be installed for the *in situ* oxidation portion of the study as described in Section 5.3. (An additional six piezometers and one extraction well will be installed for the aggressive dewatering portion of the study.) The initial round of groundwater samples from the piezometers and extraction well is the same set of groundwater samples that are proposed to be collected for the aggressive dewatering and SVE technology to establish the initial contaminant concentration configuration in the A monitoring zone.

Inputs into the decisions for the *in situ* oxidation study are presented below and include measurements to be taken presented in Table 7-3. The following activities will provide the inputs needed for the *in situ* oxidation study decision making.

6. Groundwater samples will be collected from the A zone extraction well and A zone piezometers and analyzed using method SW8260B for VOCs prior to injection of the oxidant. These data will establish the baseline groundwater contamination levels in the area of interest.

7. Groundwater samples will be collected at the extraction well during extraction and analyzed for VOCs using Method SW8260B.

8. After a sustainable level of the oxidant is present in the area of interest in the A monitoring zone, oxidant injection will cease and groundwater extraction will stop. This will allow the water levels in the A monitoring zone to return to pre-extraction levels. After the injection of peroxide has ceased and groundwater levels have stabilized, groundwater samples will be collected from the A zone extraction well and piezometers and analyzed for VOCs using Method SW8260B. All analytical data will be compared to assess the effectiveness of oxidant injection in reducing the VOC concentrations in groundwater beneath the test area in the A monitoring zone.

Step 4: Boundaries of the Study

The aggressive dewatering and SVE technology will be simulated using a groundwater model and a subsequent SVE model. The preliminary physical boundaries for both models are shown on Figure 2-7. The groundwater model boundaries will probably change during the model calibration and model simulations. The SVE model boundaries shown on Figure 2-7 may also change based on the output from the groundwater flow model. Only the area that is estimated to have been completely dewatered, based on the output from the groundwater model, will be used as the area to be modeled in the SVE model.

The other boundary identified besides the physical limits of the model are the time constraints on the model. The groundwater model will be used to simulate the optimal placement of groundwater extraction wells and optimal rate or time it will take these wells to dewater the area of interest. Time will also be used as a comparison device to determine mass removed over time for aggressive dewatering compared to the mass removed over time for conventional pump and treat technologies.

The physical boundaries of the *in situ* oxidation study zone are not completely known at this time. The oxidant will be injected into the A monitoring zone piezometers which will surround the extraction well. After the proposed aquifer test data is analyzed an approximate capture zone of the extraction well can be calculated. This capture zone will aid in determining if the oxidant impacted groundwater will be completely contained by the extraction well during the demonstration. The capture zone calculations can be used to determine the downgradient extent of capture. This calculation is essential in determining if injection of oxidant into the A monitoring zone downgradient piezometer is being captured. If it is determined that it is not being captured during the time frame of the demonstration, then injection of oxidant into the downgradient piezometer may not occur.

Step 5: Decision Rules

If the life cycle cost using an aggressive remediation strategy is equivalent or greater than the life cycle cost using pump and treat technologies, then it would not be economically feasible. The cost

effectiveness of the components of the aggressive remediation strategy will determine the overall life cycle costs of the strategy. If the life cycle cost of aggressive dewatering with SVE is greater than the life cycle cost using pump and treat technologies, then it may not be economically feasible to include this technology within the strategy. Additionally, if the cost-per-pound of contaminant (life cycle cost) removed using *in situ* oxidation technology is greater than the cost-per-pound of contaminant removed using pump and treat technologies then *in situ* oxidation may not be economically feasible for other sites at McClellan AFB.

Step 6: Limits on Uncertainty

In order to determine if the aggressive remediation strategy is feasible for remediating sites at McClellan AFB the technology must decrease the concentration of VOCs in groundwater more cost effectively when compared to pump and treat technology (>25% reduction in life cycle costs). Analytical data must meet project specifications for precision and accuracy outlined in the McClellan basewide RI/FS QAPP (Radian International, 1999c). Sensitivity analyses will be run on the critical parameters in the groundwater and SVE models. Table 8-1 presents all measurements to be collected and if they are critical. Parameters will be varied, greater and lower than the average values used. The sensitivity analyses is used to predict error constraints for the model and will be presented in the final report. These error constraints can be used to estimate the variability in the life cycle cost of the aggressive dewatering and SVE technology. There are no statistical analyses that will be applied to the aquifer test data.

Data from the *in situ* oxidation portion of the test will include an initial graphical evaluation (i.e. concentration time series for each location sampled, summary statistics) to evaluate changes in TCE concentrations throughout the duration of the test. The concentration data will also be statistically evaluated using appropriate procedures. Ideally, a means comparison to compare baseline and final concentrations will be performed. However, if the data do not meet the statistical assumptions for the tests, then alternate (*e.g.*, non-parametric) tests will be identified and used to evaluate the data. If it is determined using the above tests for aggressive dewatering with SVE and *in situ* oxidation that the concentration of VOCs in groundwater can be reduced

Groundwater samples collected after the *in situ* oxidation technology demonstration as part of the groundwater monitoring program may show increasing or decreasing concentrations of VOCs as the groundwater from upgradient moves into the area of the test. These data will not be comparable in demonstrating if the technology is successful.

Step 7: Sample Design

Soil samples will be collected during the drilling of the boreholes for the extraction wells and piezometers. The extraction wells and piezometers will then be installed and developed. Groundwater samples will be collected from the installed extraction wells and piezometers at least 2 weeks after they are developed. The A monitoring zone aquifer test will be performed first. The aquifer will be allowed to recover and then the B monitoring zone aquifer test will be performed. The aquifer will be allowed to recover and then the A and B extraction wells will be pumped at the same time for the third aquifer test. The aquifer test results and the soil and groundwater sampling results will be used to finalize the groundwater flow model calibration. The groundwater flow model will be run until an optimal number of extraction wells can dewater the area of interest in a timely manner. The final results of the groundwater flow model and the soil sample results will be used to finalize the SVE model. The SVE model will be used to determine the optimal number of soil vapor extraction wells to be used to extract the greatest

Table 8-1. Critical Items to be Measured

Measurements/ Samples[a] to be collected.	Critical or Non-critical	Evaluation of Measurement
Contaminant soil concentrations (mg/kg)	Non-critical	Will not be statistically evaluated.
Saturated hydraulic conductivity (K) of the A monitoring zone	Critical	Will not be statistically evaluated.
Saturated hydraulic conductivity of the B monitoring zone	Critical	Will not be statistically evaluated.
Unsaturated soil permeability (m^2)	Non-critical	Will not be statistically evaluated.
Porosity of the material	Non-critical	Will not be statistically evaluated.
Specific yield of the A monitoring zone	Critical	Will not be statistically evaluated.
Specific yield of the B monitoring zone	Critical	Will not be statistically evaluated.
Porosity	Non-critical	Will not be statistically evaluated.
Well extraction rate	Non-critical	Will not be statistically evaluated.
pH	Non-critical	Will not be statistically evaluated.
Conductivity	Non-critical	Will not be statistically evaluated.
Temperature	Non-critical	Will not be statistically evaluated.
Oxidation-reduction potential (ORP)	Non-critical	Will not be statistically evaluated.
Dissolved oxygen (DO)	Non-critical	Will not be statistically evaluated.
Carbonate	Non-critical	Will not be statistically evaluated.
Total suspended solids (TSS)	Non-critical	Will not be statistically evaluated.
Water levels	Non-critical	Will not be statistically evaluated.
Volatile Organic Compound (VOC) (EPA Method SW8260B)	Critical	Will be statistically evaluated using a paired t-test (See Section 4-6 for further details).
Total Carbonate (EPA Method E310.1)	Non-critical	Will not be statistically evaluated.
Total Organic Carbon (TOC) (EPA Method 415.1) in soil	Non-critical	Will not be statistically evaluated.
TOC in groundwater (EPA Method SW9060)	Non-critical	Will not be statistically evaluated.

Critical = Measurement is quantifiable and necessary to make decisions.

amount of contaminants from the dewatered zone in a timely manner. The groundwater model will be run after the SVE model to simulate the rewetting of the area and the contaminant transport in the groundwater. Outputs from the groundwater model and the SVE model will be used to estimate the life cycle costs of using aggressive dewatering to remediate a groundwater site at McClellan AFB.

Based on the A zone TCE isopleths (Figure 2-8) and surrounding well analytical data, it was estimated that the concentration of TCE in the groundwater at the test site may be approximately 50 µg/L. The removal rate of VOCs varies throughout the in situ oxidation procedure and is a function of the various volumes of peroxide, TCE, and other geochemical parameters in the aquifer. The removal rate is also a function of fate and transport (e.g. permeability, gradient, pumping rates and the distance between the extraction well and the injection points). During the in situ oxidation test, a decreasing trend followed by an increasing trend in TCE concentrations is anticipated. The initial decrease in TCE concentrations occurs as the peroxide reacts with the VOCs. After the peroxide injection is stopped and the peroxide concentrations decrease (due to degradation, chemical reactions with VOCs and other constituents in the aquifer, and extraction along with the pumped groundwater), concentrations of VOCs begin to increase as they are replenished from upgradient sources. Therefore, groundwater samples will be collected in greater numbers and frequency in the beginning of the test and then decreasing frequency as the test progresses. A total of 23 groundwater samples will be collected from the extraction well and surrounding injection wells as shown in Table 7-3 and analyzed by Method SW8260B for VOCs.

8.2 MEASUREMENTS

Table 8-2 shows the number measurements to be taken for the aggressive remediation strategy described in this WIP.

8.3 KEY PERSONNEL

The following are the key personnel assigned to this task:

- Mr. Jim Lu, SM-ALC/EMR, is the Quality Assurance Evaluator (QAE) and Remedial Project Manager (RPM) for the demonstration project. Mr. Lu is the primary point of contact for technical issues with McClellan AFB subcontracts and is responsible for technical oversight of the demonstration project.

- Mr. Tim Chapman, TRW, is a support contractor for the NETTS location. Mr. Chapman's responsibilities include providing independent technical oversight and quality assurance support to the demonstration project for McClellan AFB.

- Ms. Deena Stanley, Radian International, is the project manager for the project. Ms. Stanley's duties include providing guidance and technical oversight of the field activities, including drilling activities, aquifer tests, and sampling and analysis efforts conducted under contract to McClellan AFB.

- Ms. Elise Willmeth, Radian International, is the task leader for the aggressive dewatering with SVE and the *in situ* oxidation activities. Ms. Willmeth's responsibilities include organization and technical direction of both activities and collaboration and cooperation with the *in situ* oxidation point of contact.

- Ms. Joy Rogalla, Radian International, is the QA staff manager for the project. Ms. Rogalla's duties include providing guidance and oversight of quality assurance.

Table 8-2. Measurements to be Taken for the Aggressive Remediation Strategy

	Measurements/ Samples[a] to be Collected	Number of Measurements for Aggressive Dewatering Data Gap Investigation	Number of Measurements for *In Situ* Oxidation System Operation	Total Number of Samples/ Measurements
Based on analytical calculations	Contaminant soil concentrations (mg/kg)	1	-	1
Field Measurements	Saturated hydraulic conductivity (K) of the A monitoring zone	1	-	1
	Saturated hydraulic conductivity of the B monitoring zone	1	-	1
	Unsaturated soil permeability (m^2)	1	-	1
	Porosity of the material	1	-	1
	Specific yield of the A monitoring zone	1	-	1
	Specific yield of the B monitoring zone	1	-	1
	Porosity	1	-	1
	Well extraction rate	1	-	1
	pH	20	32	52
	Conductivity	20	32	52[b]
	Temperature	20	32	52[b]
	Oxidation-reduction potential (ORP)	-	32	32
	Residual peroxide	-	32	32
	Dissolved oxygen (DO)	-	32	32
	Water levels	[b]	[b]	[b]
Samples for Laboratory Analysis	Volatile organic compound (VOC) (EPA Method SW8260B)	20	27	43[c]
	Total carbonate (EPA Method E310.1)	-	4	4

Table 8-2. (Continued)

Measurements/ Samples[a] to be Collected	Number of Measurements for Aggressive Dewatering Data Gap Investigation	Number of Measurements for *In Situ* Oxidation System Operation	Total Number of Samples/ Measurements
Total organic carbon (TOC) (EPA Method 415.1) in soil	20	-	20
Total suspended solids (TSS)(EPA Method E160.2)	-	4	4
Bulk density (D2937)	20	-	20
TOC in groundwater (EPA Method SW9060)	-	4	4

[a] All measurements/samples for groundwater unless specified otherwise.
[b] Numerous water level measurements will be collected during the aquifer tests described in Section 5.0.
[c] A total of 20 samples will be collected for the aggressive dewatering data gap investigation (see Tables 7-1 and 7-2 for specific details on aggressive dewatering sampling), and 27 samples for the *in situ* oxidation technology (see Table 7-3 for specific details on *in situ* oxidation sampling). An overlap of four samples will be collected for both the *in situ* oxidation and aggressive dewatering technologies.

Note: Detection limits are presented in Section 8.0 of the Basewide RI/FS QAPP (Radian International, 1997). In addition to the number of VOC samples, quality control samples will also be collected as stated in Section 8.7.2.

The appropriate contact staff from the analytical laboratories to be used for this effort will be identified in the final WIP.

8.4 QUALITY ASSURANCE OBJECTIVES

Quality assurance objectives (QAOs) are related data quality planning and evaluation tools for all sampling and analysis activities. A consistent and comprehensive approach for developing and using these tools is necessary to ensure that enough data are produced and are of sufficient quality to make decisions.

8.4.1 Data Quality Categories

To guide analytical planning during DQO and field sampling plan (FSP) development, two general analytical data quality categories are defined: (1) screening analysis with definitive confirmation, and (2) definitive analysis. These two categories will be used for this project.

Screening with definitive confirmation includes data produced by rapid field screening methods that are less precise or quantitative than standard analytical methods, often with less rigorous sample preparation or analytical quality control. Screening level methods identify analytes or classes of analytes often at higher quantitation limits. For this project, screening methods will be used to collect water level, dissolved oxygen, oxidation reduction potential, residual peroxide, conductivity, and pH measurements.

Definitive data are produced using standard U.S. EPA or other reference methods, usually in an off-site laboratory (some laboratories are certified to perform definitive analyses in a mobile laboratory). Data are analyte-specific, and both identification and quantitation are confirmed. These methods have standardized QC and documentation requirements providing information needed to verify all reported results. Definitive data are not restricted for use unless quality problems are documented and result in specific limitations and data qualification. EPA Method SW8260B, SW9060, E415.1, E160.1, E310.1, and ASTM D2937 will be used to provide definitive data for this project.

8.4.2 Quality Assurance Objectives

QAOs are the detailed QC specifications for precision, accuracy, representativeness, comparability, and completeness (PARCC). The QAOs established in this QAPP were used to develop this work plan and will be used as part of the data quality review.

Precision and accuracy objectives are presented in Table 4-11 of the basewide RI/FS QAPP for laboratory control samples (LCSs), laboratory duplicates, field duplicates, matrix spike (MS), and matrix spike duplicate (MSD) samples for laboratory analytical methods and matrices. The LCS objectives are the minimum criteria that the laboratory will meet to indicate the analytical system is performing within acceptable limits. Precision and accuracy objectives for field measurements (except ORP) are presented in Table 4-1 of the basewide RI/FS QAPP. The ORP precision and accuracy objectives will be obtained from the manufacturer's specifications prior to beginning the field activities.

Completeness will be calculated for each method for all samples collected during the monitoring activity. Completeness for the data set is defined as the percentage of results usable for data interpretation and decision making. Results determined to be unusable, or that were not reported because of sample loss, breakage, or analytical error, negatively influence completeness and are subtracted from the total number of results to calculate completeness. The overall objective for completeness is 95% for all samples and measurements.

Comparability is the confidence with which one data set can be compared to another similar data set. The precision and accuracy objectives, quantitation limits, field procedures, and guidelines presented in this QAPP have been established to attain the greatest possible degree of comparability. Comparability is achieved by meeting the precision and accuracy specifications, using standard methods for sampling and analysis and data review, reporting data in standard units, and using standard reporting formats.

8.5 ANALYTICAL PROCEDURES AND CALIBRATION

This section briefly describes the analytical methods and calibration procedures for samples that will be collected during this project. Field instrument calibration procedures are presented in Section 7.0 of the basewide RI/FS QAPP (Radian International, 1999b).

Analyses of VOC concentrations in water samples will be performed using methods published in the U.S. EPA *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846*, Third Edition, revised December 1996, Update III (U.S. EPA, 1996). Descriptions of each method used for this project are presented below.

The project quantitation limits (QLs) presented in Tables 8-1, 8-2, and 8-9 of the basewide QAPP are appropriate for this effort. These QLs should be considered as maximum allowable reporting limits to be

used for laboratory data reporting; data produced by different laboratories will comply with these maximum levels. Accuracy specifications for field instrumentation are presented in Table 4-1 of the basewide RI/FS QAPP (Radian International, 1999c) and Appendix C.

8.6 DATA REDUCTION, VALIDATION, AND REPORTING

The laboratory data reduction, validation, project data management activities, and reporting procedures ensure that complete documentation is maintained, transcription and reporting errors are minimized, and data received from laboratories are properly reviewed.

8.6.1 Laboratory Data Reduction and Verification

The specific data reduction, verification, and reporting procedures must be performed by each laboratory to ensure that accurate and consistent data handling, review, and reporting are achieved. The laboratory analyst performing the analyses is responsible for the reduction of raw data generated at the laboratory bench to calculate sample concentrations. For many methods, data reduction software is included with the instrument or Laboratory Information Management System (LIMS). In those cases, the analyst must verify that the data reduction was correct. The system may require manual manipulation to correctly calculate sample concentrations.

The analytical process includes verification or a QA review of the data. Specific requirements, acceptance criteria, and corrective actions for each method are included in Section 8.6. This includes:

- Reviewing transport and receipt temperatures for volatile organic analysis (VOA) samples.
- Verifying the calibration or calibration check sample for compliance with laboratory and project criteria.
- Verifying that batch QC samples were analyzed at the proper frequency and that results were within specifications.
- Comparing raw data (chromatograms, etc.) with the reported concentrations for accuracy and consistency.
- Verifying that the holding times were met and that reporting units and quantitation limits are correct.
- Determining whether corrective action was performed and control was re-established and documented prior to analysis of QC or project samples.
- Verifying that all project and QC sample results were properly reported and flagged.
- Preparing batch narratives that adequately identify and discuss any problems encountered.

Analytical data will be received electronically from subcontracting laboratories. Specific data fields and file formats will be established and tested prior to sample analyses. This ensures that the formats are compatible with the existing project database and all required information is reported in compliance with project and Air Force requirements.

After being loaded into the database, data are available for QC data review and preliminary data use. A QA review of the database will be performed by comparison with laboratory data reports, field data forms, and other data sources. At a minimum, 10% of the results will be compared with the laboratory hard copy reports to verify correct data transfer. If systematic discrepancies or an unacceptably high rate of random errors are found, the frequency will be increased to ensure that all information has been correctly added. Corrective actions will be identified and implemented if systematic or high random error rates occur.

8.6.2 Project Data Review and Validation

The QA staff or other designated staff members perform data quality review and validation. Project data review includes, at a minimum:

- Chain-of-custody review.
- Holding time compliance evaluation.
- Adequate batch QC frequency for all data.
- Review of all batch QC and field QC sample results for compliance with objectives established in this QAPP.

8.6.3 Data Reporting

The following procedures will be employed to ensure general reporting quality for interpretive reports:

- Technical peer review for technical accuracy and organization.
- Field data not provided by an outside laboratory will be entered into electronic files and verified by the person who initially provided the data.
- All calculations and measurements are verified by the person who initially provided the data. The calculations and measurements are then independently reviewed and verified by another individual. Calculations are documented on a formatted calculation sheet with headings to identify the activity, project, and individual performing the work, and sign-off blocks for reviewers. Any calculations and measurements that differ from the initial results are resolved by both individuals and documented on the calculation sheet. Calculations and measurements included in an internal working copy are rechecked during peer review.
- Numerical values presented in reports and comparisons of numbers appearing in text, tables, and appendices are addressed in the manner discussed above. Technical editors check all reports for proper format, grammatical correctness, and correct references to figures, tables, sections, and appendices.

Records will be maintained in logbooks and on laboratory and field forms for all field activities as specified in the basewide QAPP and this WIP. The following forms may be used to record the data generated at the site:

- Daily Field Logs.
- Geologic Field Logs.
- Health and Safety Data Sheets.
- Well Development Data Sheets.
- Aquifer Test Data Sheets.

Site activity data will be kept in the field logbook. The permanent field logbook will be a bound book with consecutively numbered pages that will be suitable for submission as evidence in legal proceedings. The logbook will be used and maintained on a daily basis with all entries in permanent ink. These data will be used in the economic analysis.

Reporting practices for analytical data include:

- Headings that uniquely identify samples and the analytical method.
- Date sampled and analyzed.
- Consistent units of measure.
- Consistent number of significant figures.
- Quantitation limit.
- Method detection limit.
- Practical quantitation limit.
- Dilutions performed (if applicable).
- Data qualifier flags.
- Use of footnotes to designate special conditions or exceptions.

Measurement data generated during an investigation are reported in tabular form to support data use and interpretation. In general, data will be presented according to sampling location, analytical method, parameter, or matrix.

The data collected for this McClellan AFB project will also be provided in a format compatible with the latest version of the Environmental Resources Program Information Management System (ERPIMS) Data Loading Handbook. The ERPIMS data management system is designed to accommodate all types of data collected for IRP programs. Specific codes and data forms have been developed to allow consistent and efficient input. Additionally, copies of gas chromatography/mass spectrometry (GC/MS) data from the analytical laboratories will be provided to McClellan AFB on CD-ROM (read-only) along with the other electronic deliverables.

The McClellan AFB database information is provided to the U.S. Air Force via files in specified ERPIMS formats on diskettes or cartridge tapes. The information includes all required technical data such as site information and chemical analysis results.

8.7 INTERNAL QUALITY CONTROL CHECKS

Internal QC is achieved by collecting and analyzing a series of duplicate, replicate, blank, spike, and spike duplicate samples to ensure that analytical results are within the specified QC objectives. The QC sample results are used to quantify precision and accuracy and identify any problems or limitations in the associated sample results. The internal QC components of the sampling and analysis program will ensure that data of known quality are produced and documented. The internal QC checks, frequency, acceptance criteria (or references), and corrective actions required to meet project objectives for each analytical method are presented in Tables 10-1 through 10-43 in the basewide RI/FS QAPP.

Laboratory QC samples are documented at the bench and reported with the analytical results. Field QC samples are identified in the field documentation (data forms, master log) and submitted blind to the laboratory. All laboratory and field QC sample results are assessed during data review and validation.

8.7.1 Analytical Laboratory QC Samples

Laboratory QC is necessary to control the analytical process within method and project specifications, assess the accuracy and precision of analytical results, and identify assignable causes for atypical analytical results. The QC checks described below will be performed as required for each analytical method.

Calibration Standards

Initial calibration is performed using a range of calibration standards with the lowest standard near the analyte's quantitation limit. These standards are used to determine the linear dynamic range for the initial instrument calibration.

Continuing or Daily Calibration

Daily or continuing calibration checks must be performed at the frequency specified in the method. This usually involves analysis of a mid-level standard containing all analytes, and comparison of the results with the initial calibration response or curve. If the daily or continuing calibration results do not meet the method requirements, corrective action is required before field samples are analyzed.

Laboratory Control Samples

LCSs are blank (reagent water or ultra-pure nitrogen) spikes containing analytes of interest at a specified concentration, usually in the mid-calibration range. The LCS undergoes the entire sample preparation and analysis process to demonstrate that the method/instrument is stable and operating within acceptable accuracy and precision limits. LCSs are required for all chemical analytical methods at a frequency of one per analytical batch or one per 20 field samples, whichever is more frequent.

System Blanks

A system blank is a sample composed of reagent water or ultra-pure nitrogen with all the reagents or standards in the same quantities used to prepare a sample for analysis. The system blank undergoes the same sample preparation procedure as a sample. System blanks ensure that interference's from the analytical system, reagents, and glassware are under control. The required frequency for analyzing system blanks is one per day for each method/instrument and every 12-hour period.

Matrix Spikes/Matrix Spike Duplicates (MS/MSDs)

An MS is a solution of known concentrations of selected target analytes spiked into a field sample before sample preparation and analysis. An additional aliquot of the sample is spiked for the MSD analysis. The analytical results of the duplicate spiked samples are used to identify matrix interferences that influence the recovery or measurement of method analytes.

Surrogate Spikes

Surrogate spikes are analytes that do not occur naturally but behave similarly to the target analytes selected for most organic analytical methods. A surrogate analyte solution of known concentration is spiked into each sample, standard, blank, and QC sample prior to sample preparation and analysis. The recovery of the surrogate spike compounds is reported for each sample, and the results are compared to the recovery objectives established for the method. Surrogate spike results provide a measure of instrument and method performance and indicate sample-specific matrix effects.

Laboratory Duplicates (Duplicate Analyses)

Laboratory duplicates are repeated, independent analyses of the same sample, by the same analyst, at essentially the same time, and under the same conditions. The sample is split in the laboratory, and each fraction is carried through all stages of sample preparation and analysis. Duplicate analyses are used to assess the precision of each analytical method. Laboratory duplicates are performed to a limited number of methods, generally those for which spiked duplicate samples cannot be performed (*i.e.*, gas phase samples). Laboratory duplicates provide limited or no information if all or most analytes are not detected in the sample selected for duplication. If performed, the required frequency is one laboratory duplicate per analytical batch (up to 20 samples), or 10%, whichever is specified by the method.

8.7.2 Field QC Samples

Field QC samples are used to assess the influence of sampling procedures, equipment, and handling on the reported results. They are also used to characterize matrix heterogeneity.

Field Duplicate Samples

A field duplicate sample is a second sample collected at the same location as the original sample. Duplicate sample results are used to assess total precision and variability associated with the laboratory analysis and the sample collection process. Duplicate samples will be collected sequentially using identical recovery techniques and are treated identically during transportation and analysis. Field duplicate samples will be collected at a minimum of 10% of all samples.

Specific locations and frequency for field duplicate sample collection for site characterization are detailed in Table 7-2 of this WIP. Field duplicates should be collected over the duration of the sampling program.

Ambient Blanks

Ambient blanks for water sampling are samples of organic-free water exposed to ambient conditions and then collected and processed using the same procedures as other samples. Ambient blanks are used to assess the potential for contaminant introduction from ambient sources, and are collected only for VOC analyses.

Organic-free water used for ambient blanks will be prepared with Type II water that has been filtered, deionized, and usually boiled to volatilize organic compounds. This water is then continuously purged with nitrogen to prevent reentry of VOCs. Water to be used for VOC analysis (SW8260B) will also be kept under positive pressure by purging with nitrogen. This water should be tested to ensure purity.

Equipment Blanks

Equipment blanks use Type II water organic-free water for volatile organic analyses. The water is poured through a decontaminated sampling device, collected in the sample container, and transported to the laboratory for analysis. The number of equipment blanks collected will be 10% of all normal samples.

Trip Blanks

A trip blank is a sample of organic-free water (prepared as for ambient blanks) placed in the sample container in an uncontaminated laboratory area prior to field work. Trip blanks are prepared only for water samples being analyzed for VOCs and are handled as field samples are handled. Trip blank results are used to identify contamination from sample containers or transportation and storage procedures. One set of trip blanks will accompany each cooler containing samples for VOC analysis.

8.7.3 Sample Custody and Documentation

Sample possession during all sampling efforts must be traceable from the time of collection until the results are verified and reported by the laboratory and the samples are disposed. Sample custody procedures provide a mechanism for documenting information related to sample collection and handling. Each step or aspect of sample custody and documentation is described in this section.

The field operations coordinator for Radian International is responsible for ensuring that field sampling teams adhere to proper custody and documentation procedures. Pre-formatted field data and chain-of-custody (CoC) forms are the primary documentation mechanisms used to record and track information about each sample. Copies of the CoC and field data forms are retained in the project files. Field personnel have the following responsibilities:

- Keep accurate written records of sample collection activities on the field and logbooks.
- Ensure that all entries are legible, written in waterproof ink, and contain accurate and inclusive documentation of the field activities. This documentation includes field data and observations, any problems encountered, and actions taken to solve the problem.

- Date and initial daily entries.

- Note errors or changes using a single line to cross out the entry, and date and initial the change.

- Complete CoC forms accurately and legibly. Field forms and logbooks are available for review during technical systems audits or at any other time for QC checks. This documentation provides verification of sampling procedures.

Sample Labels and Identification

A sample label is affixed to each sample collected and will be identified as stated in the basewide RI/FS QAPP, Section 5.2.6 (Radian International, 1999b). Sample labels uniquely identify the sample with an identification number, the sample type, analytical method requested, the sampler's name(s), and date collected, and the preservation method used. These labels are completed with indelible ink. Labels that have pre-printed sample identification numbers (IDs) may be used; the remaining information is then completed at the time of sample collection.

8.8 PERFORMANCE AND SYSTEM AUDITS

One field audit will be performed during the project. This will be a blind audit performed sometime during the early portion of the aquifer testing phase of the field activities.

All subcontractor laboratories chosen to perform analytical work must be certified by the state of California. No on-site technical systems audit will be conducted for this project because laboratories undergo frequent technical systems audits conducted internally as well as by various state and federal clients. Copies of the most recent state certification audit reports as well as any recent federal audit reports will be requested and reviewed prior to the startup of this project. Any similar audits performed for other McClellan AFB projects will also be reviewed. Copies of the laboratory's U.S. EPA WP and WS series audits will be requested and reviewed as part of the laboratory performance review process.

One performance evaluation (PE) sample will be submitted to the laboratory prior to fieldwork unless a PE sample submitted as part of the McClellan AFB Groundwater Monitoring Program (GWMP) has been evaluated within the three months prior to field work associated with this task. In this case, the results of the previous PE sample and associated GWMP QA/QC evaluations will be used to judge laboratory performance. One PE sample will be submitted as a field sample (double-blind) during the course of the project to evaluate whether the laboratory is operating within project control limits specified in the McClellan AFB basewide RI/FS QAPP (Radian International, 1999).

8.9 CALCULATION OF DATA QUALITY INDICATORS

Data quality assessment procedures are described in the basewide QAPP SOP #McAFB-028 (Radian International, 1999c) and include statistical calculations for precision, accuracy, completeness, and method detection limits.

8.10 CORRECTIVE ACTION

During the McClellan AFB technology demonstration program, the project manager, quality assurance coordinator (QAC), field managers, and sampling team members must see that all measurements and field procedures are followed as specified in this QAPP, and measurements meet the prescribed acceptance criteria. If a problem arises, prompt action to correct the problem is imperative. The QC chemist, QAC, or a data management staff member initiates the request for corrective action if QC results exceed method or project criteria, reporting or flagging errors are identified, or requested information has not been reported. Laboratory response usually involves reissuing laboratory reports or electronic data files. If significant data quality problems have occurred and the data are critical to decision making, samples may be reanalyzed or recollected and reanalyzed. More detailed information on corrective action procedures can be found in Section 14.0 of the basewide RI/FS QAPP (Radian International, 1997) and GWMP QAPP.

9.0 HEALTH AND SAFETY

To complete a problem-free, injury-free, and accident-free demonstration, all aspects of this work plan will be conducted according to the health and safety plan (HASP) presented in this section. All HASP information will be subtier to Code of Federal Regulations (CFR) Title 29 and California Code of Regulations (CCR) Title 8 and 40 CFR and CCR Title 22. Each organization will bear the ultimate responsibility for implementing and adhering to all safety measures for its workers and subcontractors. Work by contractors shall be conducted in accordance with the Radian International corporate health and safety program, the McClellan AFB Environmental Technology Remediation Implementation Contract (METRIC) health and safety plan, and health and safety plan addenda. When conflicts occur between this HASP and an organization's corporate HASP, the more restrictive requirements will apply.

This HASP addenda has been approved by the project manager and the health and safety manager.

Deena Stanley
Deena Stanley, Project Manager

Kim Worl, CIH
Kim Worl, Certified Industrial Hygienist,
Health and Safety Officer

9.1 OBJECTIVES

The objectives of the HASP follow:

- Assess potential site hazards before work.
- Ensure that all personnel are aware of potential hazards.
- Minimize or mitigate potential hazards.
- Provide a means to protect personnel and report incidents.
- Complete demonstration with zero reportable incidents.

9.2 HEALTH AND SAFETY ORGANIZATION AND KEY PERSONNEL

McClellan AFB Remedial Project Manager:	Jim Lu
Base Project Coordinator:	Timothy Chapman (support contractor)
Base Hazmat:	Diane Kiyota
Radian International Project Manager	Deena Stanley
Radian International Aggressive Dewatering and *In Situ* Oxidation Task Leader	Elise Willmeth

Radian International Project Health and Safety Officer:	Kim Worl (Certified Industrial Hygienist)
Site Safety and Health Officer:	Variable

9.2.1 Responsibilities of the Program Manager and Task Leader

The program manager has ultimate responsibility to ensure that the HASP is implemented and the project is executed in accordance with all applicable federal, state, and local requirements and Radian International's corporate policy.

The responsibilities of the task leader are:

- Ensure that field personnel, including subcontractor personnel, are participating in the necessary medical monitoring and are properly trained in safety, health, and emergency procedures.
- Interface with McClellan AFB personnel if problems arise that require alteration to or deviations from the HASP.
- Before site activities begin, contact the base emergency response agencies (police, fire, and medical) and advise them of the drilling activities. Verify emergency phone numbers.
- Regularly coordinate field activities with the remedial project manager (RPM) and other appropriate Air Force personnel.
- Ensure that the appropriate HASP and addenda are available on site.
- Ensure that safety and health equipment is procured on time and available for field use.
- Coordinate reporting any accidents or injuries.
- Locate the support facilities in an uncontaminated area.
- Implement the safety, health, and emergency response training described in Section 9.5 of this HASP.
- Ensure that the exposure monitoring plan (Section 9.6) is implemented as appropriate.
- Ensure that all Radian International personnel correctly select and use personal protective equipment (PPE) and apply safety practices appropriate to the site-specific conditions.
- Monitor subcontractor compliance with accepted health and safety procedures.
- Take the appropriate action as described in this HASP for accidents, fires, or other emergency situations.
- Conduct periodic safety review sessions for the drilling crew and other on-site personnel.

- Ensure that safety equipment is properly maintained or disposed.

- Initiate corrective action for observed safety violations and report unsuccessful attempts to correct a violation to the program manager.

9.2.2 Responsibilities of the Project Health and Safety Officer

The project health and safety officer shall:

- Have overall independent health and safety responsibility and oversight for this effort.

- Prepare the HASP and addenda.

- Conduct periodic site safety audits.

- Review subcontractor HASPs to resolve conflicts with Radian International's HASP or planned activities that may jeopardize on-site personnel. This review does not endorse or approve the subcontractor's standard operating procedures (SOPs) or HASPs. Verify that all subcontractors' HASPs comply with the requirements of this task under basic contract.

- Review and confirm any changes in personal protective clothing or respiratory protection requirements.

- Advise about the use of site health and safety sampling equipment.

- Consult with the task leader and site safety officer (SSO) in the field about any problems implementing the HASP.

9.2.3 Responsibilities of the Site Safety Officer

The site safety officer SSO will be responsible for field execution of the safety, health, and emergency response procedures described in this HASP and will report directly to the project task leader. The responsibilities of the SSO are to:

- Monitor airborne contaminants as specified in Section 9.6 of this HASP.

- Take appropriate action regarding accidents, fires, or other emergency situations.

- In the absence of the task leader, monitor subcontractor compliance with accepted health and safety procedures.

- Ensure that daily work schedules integrate heat and cold stress prevention measures.

- Ensure that the field team observes the work zone and decontamination procedures as described in this HASP.

- Ensure proper handling and shipping of potentially hazardous samples (as described in Section 7.0).

- Stop work if unsafe conditions exist.

- Conduct daily tail gate health and safety briefings.

During drilling operations, the Radian International supervising rig geologist (SRG) will also be assume the role of the SSO.

9.2.4 Responsibilities of the Field Team

The responsibilities of the field team members with respect to health and safety are to:

- Read and understand this HASP (including the Site-Specific Spill Plan – Appendix E). All Radian International and subcontractor field personnel will sign a statement that they have read and will comply with the HASP (Figure 9-1).

- Perform work safely.

- Report any unsafe conditions or other health and safety concerns to the SSO.

- Suggest improved work practices or safety procedures to be practiced in the field to the task leader or project health and safety officer.

- Be aware of and alert for signs and symptoms of exposure to site contaminants and/or heat or cold stress.

9.2.5 Responsibilities of the Subcontractor Supervisors

A firm or individual subcontracted to Radian International is responsible for meeting all contractual agreements and for providing a safe and healthy workplace for its employees.

Subcontractors, as contractually required, must develop and implement a HASP specific to their work. The plan must comply with all applicable Occupational Safety and Health Administration (OSHA) health and safety regulations (29 CFR 1910/1926) and any project-specific requirements Radian International has specified. Subcontractors will provide Radian International with a copy of their HASP for review prior to beginning work. Radian International will review the subcontractor HASP for adequacy and consistency with the appropriate HASP for this effort and ensure that the subcontractors HASP complies with the requirements of appropriate federal, state, and local regulations. The subcontractors HASP will also be required to be at least as stringent as this HASP. The field coordinator will monitor the subcontractor's performance regarding health and safety issues to evaluate their compliance with their HASP and to ensure that their activities do not jeopardize the health and safety of any employees or visitors to the job site. The SSO and/or field coordinator have the responsibility and authority to remove subcontractor staff from the job site should they create an unsafe condition. In the absence of the field coordinator, the SSO will assume this responsibility. Any concerns will be brought to the attention of the subcontractor and the project task leader.

Failure to immediately correct the situation or continued disregard will result in a stop of all field activity and must be reported to the project manager and McClellan AFB staff.

RADIAN INTERNATIONAL LLC

Health and Safety Plan Project Acceptance Form

INSTRUCTIONS: This form is to be completed by each person who works on the subject work site and returned to the project task leader.

Job Number ______________________________

Client/Project ______________________________

Date ______________________________

I represent that I have read and understand the contents of the METRIC Health and Safety Plan (HASP) and this HASP and agree to perform my work in accordance with it.

____
Signature

____
Print Name

____
Company Name

____
Date

Figure 9-1. Example Health and Safety Plan Project Acceptance Form

All on-site subcontractor supervisors will be responsible for performing the duties below:

- Ensure that subcontractor employees have completed 40 hours of health and safety training in accordance with the OSHA Standards for General Industry (29 CFR 1910.120).
- Ensure that subcontractor employees have appropriate medical clearance as required by 29 CFR 1910.120.
- Provide Radian International with documentation of all required training and medical exams before the start of work.
- Provide all necessary safety equipment in good working order.
- Enforce the safety, health, and emergency response procedures presented in the HASP provided by that subcontractor.
- Initiate any corrective actions and, as appropriate, disciplinary and/or dismissal measures.
- Perform daily equipment and site safety inspections.

9.3 HAZARD ASSESSMENT

Several potential hazards may exist during the course of the demonstration. These hazards are inherent to the scope of work and system operation described in this work implementation plan (WIP). Staff have a duty to recognize additional potential hazards throughout all phases of field work. The identified potential hazards presented in the following subsections is not intended to be a comprehensive listing of all potential hazards, but represents the expected hazards specific to this task.

9.3.1 Chemical Hazards

The evaluation of chemical hazards is based upon the knowledge of site background and risks anticipated during the field investigation. The chemical hazards associated with on-site remediation activities include volatile organic compounds (VOCs) found in soil and groundwater. These potential hazards will be mitigated in the field using PPE (refer to Section 9.4.1) and air monitoring to identify hazardous atmospheres. The following paragraphs describe potential chemical hazards associated with this task and the necessary precautions to be taken.

Liquid or Vapor Waste VOCs

Soil and groundwater may contain VOCs. Site activities will involve sampling groundwater for chemical analysis and pumping groundwater for aquifer tests. Major contaminants of concern include:

- Trichloroethene (TCE).
- Tetrachloroethene (PCE).
- 1,2-Dichloroethene (DCE).
- 1,1-Dichloroethene (DCE).

- Vinyl chloride.
- 1,1,1-Trichloroethane (TCA).
- 1,2-Dichloroethane (DCA).
- Chloroform.

Table 9-1 lists the chemical hazards associated with these contaminants and with hydrogen peroxide (which will be stored on site and used for the oxidant injection technology). It is possible that other VOCs may exist in concentrations exceeding permissible exposure limits at certain pumping/sampling intervals. For this reason, safety precautions and procedures will be established by this HASP at a level of protection to guard against the possibility of exposure from such an occurrence. Exposure to VOCs is anticipated to be extremely low due to the slow rate of vaporization from soil and groundwater, short sampling intervals during which vapors may escape, and the fact that all field activities will be conducted outdoors where ambient ventilation will allow rapid dilution and dissipation of potential chemical emissions. Nonetheless, the safety precautions described in this HASP must be followed to prevent unnecessary exposure to contaminants.

Personnel may come in contact with groundwater or vapor contaminants during drilling, aquifer testing, and sampling. Precautions to prevent exposure to harmful levels of chemicals will include the usage of PPE. A direct-reading instrument, such as a photoionization detector (PID), will be available and calibrated daily during sampling operations to measure any chemical vapor emissions. Air purifying respirators will be worn if airborne chemical concentrations exceed established criteria (see Table 9-1).

Only the project health and safety officer or the SSO has the authority to downgrade or upgrade PPE. During operation of the system, personnel will follow these precautions:

- Avoid unnecessary contact with the contaminated soil, groundwater, or vapor.
- Wear appropriate PPE, such as inner and outer chemical-resistant gloves, boots, apron, coveralls, splash goggles, or shield and air-purifying respirator with organic vapor/acid gas (OVA) filter cartridges, as required by this plan, when contact with soil cuttings or liquid waste can occur.
- Periodically check system integrity to prevent leaks or spills.
- Use an organic vapor monitor (OVM) at all times during drilling and sampling sessions to measure airborne chemical vapor concentrations.

Sample Preservatives

Hydrochloric acid (HCl) will be used as chemical preservatives for water sample preservation. HCl is a strong acid and should be handled with care. The acid will be supplied in prepreserved vials (*i.e.*, vials with acid already present within) and will be provided by the laboratory. Refer to the appropriate material safety data sheet (MSDS) for handling precautions and first aid response. Store acids in a dry place and prevent contact with moisture, bases, metals, and oxidizers. Storage cabinets containing acids should be labeled as follows:

Table 9-1. Chemical Hazards of Contaminants of Concern

Chemical Name	Exposure Limit[1]	Routes of Exposure	Signs and Symptoms of Exposure	Target Organs
Chloroform (Trichloromethane)	2 ppm [2] 10 ppm [3] 2 ppm/60 min. [4]	inhalation, absorption, ingestion, skin contact	Irritation of the eyes and skin, dizziness, mental dullness, nausea, confusion, headache, fatigue, anesthesia, enlarged liver, carcinogen	Liver, kidneys, heat, eyes, skin, central nervous system (liver and kidney cancer in animals)
1,2-Dichloroethene	200 ppm [2],[3],[4]	inhalation, absorption, ingestion	Irritation to the eyes and respiratory system; central nervous system depression	Eyes, respiratory system, central nervous system
1,1-Dichloroethene (Vinylidene Chloride)	1 ppm [2] 5 ppm [3] lowest detectable level [4]	inhalation, absorption, ingestion	Irritation to the eyes, skin and throat, dizziness, headache, nausea, dyspnea, liver, kidney dysfunction, pneumonitis, carcinogen	Eyes, skin respiratory system, central nervous system, liver and kidneys
1,2-Dichloroethane (Ethylene Dichloride)	1 ppm [2] 10 ppm [3] 1 ppm [4]	inhalation, absorption, ingestion, skin contact	Irritation to the eyes, corneal opacity, central nervous system depression, nausea, vomiting, dermatitis; liver kidney and cardiovascular system damage	Eyes, skin, kidneys, liver, central nervous system, cardiovascular system, (forestomach, mammary gland and circulatory system cancer in animals)
Tetrachloroethene, Perchloroethene (PERC, PCE)	25 ppm [2] 50 ppm [4]	inhalation, absorption, ingestion	Irritation to the eyes, nose and throat, nausea, flush face and neck, vertigo, dizziness, incoherence, headache, skin erythema, liver damage, carcinogen	Eyes, skin, respiratory system, liver, kidneys, central nervous system (liver tumors in animals)
1,1,1-Trichloroethane (Methyl Chloroform)	350 ppm [2],[3] 350 ppm/15 min. [4]	inhalation, absorption, ingestion, skin contact	Irritation of the eyes and nose; central nervous system depression; liver and kidney damage; dermatitis (carcinogen)	Eyes, respiratory system, central nervous system, liver, kidneys (liver tumors in animals)
Trichloroethene (TCE)	50 ppm [2],[3] 250 ppm [4]	inhalation, absorption, ingestion	Irritation of the eyes and skin, nausea, vertigo, dizziness, headache, skin erythema, liver injury, visual disturbance, fatigue, giddiness, tremors, vomiting, dermatitis, cardiac arrhythmia, parasthesia	Eyes, skin, respiratory system, liver, kidneys, central nervous system
Vinyl Chloride	5 ppm [3] lowest detectable level [4]	inhalation and contact with liquid	Weakness, abdominal pain, gastrointestinal bleeding, enlarged liver, pallor or cyanosis of extremities; liquid can cause frostbite, carcinogen	Liver, central nervous system, lymphatic system, liver cancer
Hydrogen Peroxide [5]	1 ppm [2]	inhalation, dermal contact	Strong oxidizer irritating to eyes, skin, and respiratory tract. Produces corneal ulcers and dermal degradation.	Mucous membranes, eyes, nose, respiratory tract, and skin.

(1) Source: Lewis, R.J. Hazardous Chemicals Desk Reference (1997)
(2) OSHA permissible exposure limit (PEL)
(3) American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV)
(4) National Institute for Occupational Safety and Health (NIOSH) recommended exposure level (REL)
(5) Process chemical

OSHA = Occupational Safety and Health Act
ppm = parts per million

POISON

DANGER

CORROSIVE

Process Chemicals

The *in situ* oxidation process requires that aqueous hydrogen peroxide (10%) be injected into the subsurface. Hydrogen peroxide is a strong oxidizer and represents a significant potential health hazard to workers at the site. The primary health hazards are associated with dermal (or eye) contact with the liquid hydrogen peroxide or inhalation of airborne hydrogen peroxide aerosol. Potential worker exposures to hydrogen peroxide will be controlled through effective engineering controls, safe work practices, and PPE. Refer to MSDS for handling requirements, PPE, precautions, and first aid response.

First Aid

In the event of contact with the contaminants of concern listed above and in Table 9-1, contact emergency response personnel immediately. Emergency response personnel should follow the first aid procedures as outlined in the appropriate MSDS.

9.3.2 Physical Hazards

Physical hazards are inherently present during project field activities. Common physical hazards include mechanical hazards, noise exposure associated with mechanical equipment use, slip-trip-fall hazards associated with the field environment, hazards associated with weather conditions, musculoskeletal injury resulting from lifting tasks, nuisance dusts associated with soil disturbance, and explosion or electrical hazards from the contaminants present or underground pipes or utility lines that may be encountered during drilling and sampling activities. The typical physical hazards anticipated to be present on the site and the methods for preventing injury due to these hazards are described below.

9.3.2.1 Noise

A noise hazard is presented from nearby airplanes, drilling activities, or other field activities associated with this field effort. Hearing protection must be provided when noise levels are identified as exceeding 85 decibels (dBA) (*i.e.*, whenever you have to raise your voice above normal conversational speech to be heard) over an 8-hour period. Radian International has measured the noise levels associated with hollow-stem auger drilling. The noise level of the rig will not equal or exceed an 8-hour time-weighted average (TWA) sound level of 85 dBA; therefore, hearing protection is optional. However, some activities such as reverse-circulation air percussion drilling have measured TWA sound levels that exceed 85 dBA. Therefore, hearing protection must be worn. Hearing protection will also be worn in the vicinity of generators or any other high noise-emitting equipment. If hearing protection upgrades are deemed necessary by the SSO, they will be provided to personnel working in the noise hazard area. Refer to 29 CFR 1910.95 for additional information on noise exposure.

9.3.2.2 Slip-Trip-Fall Hazards

Slip-trip-fall hazards are common at most sites. While it is difficult to eliminate all slip-trip-fall hazards, risk of injury will be minimized by implementing safe work practices, utilizing proper foot wear, keeping the work area free from obstructions, and good housekeeping practices.

9.3.2.3 Lifting Hazards

Field operations often require the performance of laborious tasks. All employees must implement proper lifting procedures, such as keeping the load close to the body and using leg muscles instead of back muscles to perform lifting tasks. Additionally, employees shall not attempt to lift large, heavy, or awkwardly shaped objects without assistance.

9.3.2.4 Heat Stress

Care must be taken in order to prevent workers from being overcome by heat stress due to the anticipated weather conditions and the added stress of the protective gear. All project tasks will be adjusted to minimize the heat stress potential during times when ambient conditions present the potential for a heat-related illness.

Frequency of breaks will be based upon individual worker conditions and needs, as well as ambient air temperatures and may be mandated by the SSO. Shade, cool water, and electrolyte solution will be provided at the site. Workers will be observed for potential problems prior to their resuming work after breaks.

Monitoring Workers for Heat Stress

For workers wearing permeable clothing, follow recommendations for monitoring requirements and suggested work/rest schedules in the current American Conference of Governmental Industrial Hygienists (ACGIH) *Threshold Limit Values for Heat Stress*. For workers wearing semi-permeable or impermeable clothing, the ACGIH standard cannot be used. For those situations, workers should be monitored when the temperature in the work area is above 70 degrees Fahrenheit (°F) (21 degrees Celsius [°C]). Monitor the following criteria:

- **Heart rate.** Count the radial pulse during a 30-second period as early as possible in the rest period. If the heart rate exceeds 100 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same. If the heart rate still exceeds 100 beats per minute at the next rest period, shorten the following work cycle by one-third.

- **Oral temperature.** Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking). If the oral temperature exceeds 99.6°F (37.6°C), shorten the next work cycle by one-third without changing the rest period. If the oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following work cycle by one-third. Do not permit a worker to wear a semi-permeable or impermeable garment when his/her oral temperature exceeds 100.6°F (38.1°C).

- **Body water loss, if possible.** Measure body weight on a scale accurate to ±0.25 pounds at the beginning and end of each day to see if enough fluids are being taken to prevent dehydration. Weights should be taken while the employee is in minimal clothing. Body water loss should not exceed 1.5% of the total body weight in any given work day.

Initially, the frequency of physiological monitoring depends on the air temperature adjusted for solar radiation and the level of physical work. The length of the work cycle will be governed by the frequency of the required physiological monitoring. The suggested frequency of physiological monitoring for fit and acclimated workers is as follows:

Adjusted Temperature [1]	Normal Work Ensemble	Impermeable Ensemble
90°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5–90°F (30.8–32.2°C)	After each 60 minutes of work	After each 30 minutes of work
82.5–87.5°F (28.1–30.8°C)	After each 90 minutes of work	After each 60 minutes of work
77.5–82.5°F (25.3–28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5–77.5°F (22.5–25.3°C)	After each 150 minutes of work	After each 120 minutes of work

[1] Calculate the adjusted air temperature (t_{adj}) by using the following equation: t_{adj}(°F) = t (°F) + [13 x (% sunshine)]. Measure air temperature (t) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate % sunshine by judging the fraction of time the sun is not covered by clouds thick enough to produce a shadow (100% sunshine = no cloud cover and a sharp, distinct shadow; 0% sunshine = no shadows).

Heat Stress Symptoms

If workers are not monitored for heat stress, work activities in hot environments can result in heat rash, heat cramps, heat exhaustion, or even heat stroke.

- Heat rash may result from continuous exposure to hot or humid air.

- Heat cramps are caused by heavy sweating with inadequate electrolyte replacement. Signs and symptoms include:

  1. Muscle spasms; and
  2. Pain in the hands, feet, and abdomen.

- Heat exhaustion occurs from increased stress on various body organs including inadequate blood circulation due to cardiovascular insufficiency or dehydration. Signs and symptoms include:

  1. Pale, cool, moist skin;
  2. Heavy sweating;
  3. Dizziness;
  4. Nausea; and
  5. Fainting.

- Heat stroke is the most serious form of heat stress. Temperature regulation fails and the body temperature rises to critical levels. Immediate action must be taken to cool the body before

serious injury and death occur. SEEK MEDICAL ATTENTION IMMEDIATELY. Signs and symptoms are:

1. Red, hot, usually dry skin;
2. Lack of or reduced perspiration;
3. Nausea;
4. Dizziness and confusion;
5. Strong, rapid pulse; and
6. Coma.

9.3.2.5 Cold Stress

Preventative measures will be implemented during extreme cold conditions in order to prevent cold injury. Work will be altered in order to reflect these concerns during times in which conditions pose a significant threat for workers being exposed to cold stress. Workers unaccustomed to working under thermal stresses will be allowed to become acclimated. Frequency of breaks will be based upon individual worker conditions and needs, as well as atmospheric conditions. A warm, protected break area will be provided. Consideration will be given to working in the warmer times of day (during sunshine conditions). Workers will be instructed to wear adequate layered clothing underneath personal protective clothing. Drinking water and electrolyte solution will be provided at the site. Workers should self-monitor for signs and symptoms of cold stress. Special attention shall be placed on signs or symptoms of numbness in outer limbs and pale skin. Workers must report to the SSO at the first sign of altered feeling of the skin so that warming measures can be taken.

Of special note for cold stress on the site is the wearing of Tyvek suits. Disposable clothing does not breathe; therefore, perspiration is not provided with the means of evaporation. During strenuous physical activity, clothes can become wet. Wet clothes combined with cold temperatures can lead to hypothermia. If the air temperature is less than 40°F and site personnel become wet, the person must change into dry clothes. The heated break area or a personal vehicle may be utilized as a change area.

Cold Stress Symptoms

If adequate clothing is not provided and time spent in cold areas is not reduced, work activities in cold environments can result in frostbite or hypothermia.

- Frostbite is an injury resulting from exposure to cold. The extremities of the body (fingers and toes) are most often affected. SEEK MEDICAL ATTENTION IMMEDIATELY. The signs of frostbite are:

    1. Skin turns white or grayish-yellow.
    2. Pain is sometimes felt early, but subsides later. Often there is no pain.
    3. The affected part feels intensely cold and numb.

- Hypothermia is characterized by shivering, numbness, drowsiness, muscular weakness, and a low internal body temperature when the body feels warm externally. Hypothermia can lead to unconsciousness and death. SEEK MEDICAL ATTENTION IMMEDIATELY.

9.3.2.6 Weather

During storms, rain may cause slippery surfaces. Lightening may also accompany storms creating an electrocution hazard during outdoor operations. To eliminate this hazard, weather conditions will be monitored and work suspended during electrical storms.

9.3.2.7 Contact with Electricity

If mechanical equipment makes contact with electrical wires, it may or may not be insulated from the ground by the tires of the equipment. Under either circumstance, if the human body simultaneously comes in contact with the equipment and the ground, electrocution can result, causing death or serious injury. Digging permits will be obtained from the McClellan AFB point of contact prior to conducting any subsurface investigative work. As a portion of the dig permit, each sampling location will be surveyed and cleared of underground utilities prior to commencing subsurface sampling activities. Any overhead utilities will be identified and de-energized prior to drilling activities.

If the equipment makes contact with overhead or underground electrical lines, the following procedures shall be followed:

1. Personnel should not move or touch any part, particularly a metallic part, of the equipment. Anyone in the cab of the equipment should stay seated and not move, under most circumstances.

2. If it is determined that the equipment should be vacated, all personnel must jump clear and as far as possible from the equipment. Personnel must not step off—but must jump off. Do not hang on to any part of the equipment when jumping clear.

3. If you are on the ground, stay away from the equipment; do not allow others to get near the truck or rig. Seek assistance immediately from local emergency personnel.

4. When an individual is injured, and in contact with the equipment or with power lines, attempt rescue with extreme caution. If a rescue is attempted, use a long, dry, unpainted piece of wood or a long, dry, clean rope. Keep as far away from the victim as possible and do not touch the victim until the victim is completely clear of the equipment or electrical lines.

9.3.2.8 Machinery/Mechanized Equipment

System operators will inspect all equipment and maintain it for proper performance. They will perform maintenance on mechanized equipment only after proper lockout procedures. Mechanical hazards that can be encountered during drilling operations include snapping cables, being hit by equipment, becoming entwined in rotating tools, and falling objects. Similarly, pressurized lines, groundwater pumps, and rotating parts may be encountered during aquifer testing. All personnel shall be aware of the mechanical hazards present in their work area and take proper safety precautions. If physical injury occurs, personnel shall immediately call for medical assistance, then apply first aid to the injured person.

9.3.2.9 Buried Hazards

Whenever the ground is penetrated, the potential for drilling into buried hazards exists. To minimize the hazard, field personnel should take the actions listed below:

- During the planning/mobilization phase, the SRG will consult with the McClellan AFB RPM about the location of underground utility lines (gas and electrical), as well as buried drums, cylinders, or other potential hazardous items.

- If, at any time, drill cuttings indicate any signs of buried drums, cylinders, metal or concrete, cease drilling immediately and contact the task leader and the McClellan AFB point of contact for further guidance.

9.3.2.10 Confined Spaces

Field personnel will not enter confined spaces during this project. Excavations greater than 4 feet deep are considered a confined space. Entry will not be allowed without the prior approval of the project health and safety officer and a revision to this HASP.

9.3.2.11 Fire Hazards

Fire hazards include ignited brush and grass, equipment, and flammable liquids (*e.g.*, methanol). All Radian International and subcontract employees have been instructed on how to prevent and extinguish fires. Fire extinguishers will be carried in all field sampling vehicles and drill rigs. Field personnel should be extremely cautious of using equipment that could generate sparks, operating vehicles in areas with dry grass, and refueling equipment in the field. Any fires will be reported immediately to McClellan AFB personnel.

9.3.2.12 Biological Hazards

The field team should be aware that site activities, mainly in remote areas, may disturb the local wildlife population. Field personnel may, therefore, be bitten by animals and insects. Prompt first aid measures are extremely important. All field team members will be properly briefed regarding the potential for encountering wildlife as well as prompt first aid procedures in the event of insect or animal bites. Refer to the Radian International HASP for further details on biological hazards.

9.4 ENGINEERING CONTROLS

To minimize the risk of accident or injury related to the potential hazards identified in Section 9.3, the following engineering controls will be implemented.

9.4.1 Personal Protective Equipment

All personnel working on site will use a minimum of Level D protection. During drilling operations, "Modified Level D" protection will be required when working with or around hazardous chemicals. "Modified Level D" protection includes:

- Tyvek coveralls.

- Chemical-resistant steel-toed boots.
- Chemical-resistant gloves.
- Safety glasses.
- Workers will wear hard hats when working around all operating equipment and when overhead objects present a hazard.

PPE will be upgraded to Level C or modified Level C upon notification of high airborne contaminant levels as identified through real-time air monitoring. Level C will include:

- Use of a cartridge equipped air purifying respirator (National Institute for Occupational Safety and Health [NIOSH]-approved, Mine Safety Appliances (MSA) half-face respirator with MSA GMA-H cartridge or equivalent).
- Chemical-resistant apron (or Tyvek coveralls, depending on the specific activity).
- Chemical-resistant gloves.
- Safety glasses.
- Hard hat (as necessary).
- Boots/shoes (leather- or chemical-resistant, steel-toe and shank).

The minimum protection during groundwater sampling for both site characterization, *in situ* oxidation, and aquifer testing includes:

- Steel-toed boots.
- Sturdy work clothing (long pants and cotton work shirt).
- Chemical resistant gloves (nitrile).
- Safety glasses.
- Hard hat.

The minimum protection during the *in situ* oxidation hydrogen peroxide injection includes:

- Chemical-resistant steel-toed boots.
- Chemical-resistant jacket worn over sturdy work clothing.
- Chemical-resistant gloves (nitrile).
- Safety glasses.

- Face shield.
- Hard hat (when handling or potential exposure to hydrogen peroxide exists).

9.4.2 Access Restriction

Temporary fencing or caution tape will surround the work sites to prevent access by unauthorized personnel. Following the standdown of base entrance controls, potential site hazards must be removed for intruders during non-working hours if caution tape is used.

9.4.2.1 Description of Exclusion Zone

An exclusion zone will be established around the specific work for all tasks where potential chemical contamination may exist. Caution tape or safety fencing shall be used to delineate the exclusion zone during the demonstration. Following the standdown of base entrance controls, potential site hazards must be removed for intruders during non-working hours if caution tape is used.

9.4.2.2 Description of Decontamination Zone

A decontamination zone (contamination reduction zone) will be established adjacent to or near the exclusion zone (when established). As appropriate, a decontamination "pad" will be constructed with visqueen and small berms for decontamination of drilling equipment (*e.g.*, augers, samplers, etc.).

9.4.2.3 Description of Procedures for Entering Exclusion and Decontamination Zones

All personnel must have received required training as specified in 29 CFR Part 1910, and undergo a daily briefing prior to their entering into the exclusion zone or decontamination zone. All personnel must be wearing the required level of PPE as specified in the HASP prior to entering the exclusion zone or decontamination zone.

All smoking or other activities that may cause indirect ingestion of contaminants (*i.e.*, eating, drinking, or use of tobacco) will not be allowed inside of or within 100 feet of the exclusion zone or decontamination zone.

9.4.2.4 Description of Procedures for Exiting Exclusion Zone (Decontamination)

All exits from the exclusion zone must be made through the decontamination zone. Personnel will perform decontamination as outlined below.

Personnel will perform decontamination prior to removing PPE. Personnel who have not had direct contact with contaminated or potentially contaminated equipment, wastewater, or media will remove PPE and place disposable garments in a double-lined plastic garbage bag. All PPE will be temporarily stored in double-lined plastic garbage bags. Before disposal, all PPE will be made unfit for reuse (*i.e.*, arms and legs removed from Tyvek suites). When bags are full, the vapor in these bags will be monitored for contamination with field meters. In the absence of measurable contamination, the bags will be disposed of as solid waste in a waste receptacle on base. If contamination is measured above background (ambient air) levels, the PPE waste will be containerized and transferred as directed by the base for disposal. The SSO will be responsible for monitoring decontamination procedures and determining their effectiveness.

Potable water will be available on site for decontamination procedures. Personnel who have had contact with potentially contaminated equipment or media will perform the following process as necessary:

- Wash and remove exposed garments.
- Rinse exposed equipment with Alconox and potable water.
- Place disposable garments in double-lined garbage bags.

All personnel must have an extra set of clothing on site in the event that their clothing becomes contaminated.

Respirators, if used, will be cleaned, air-dried, and placed in sealed plastic bags. Cartridges will be discarded after use (in accordance with Radian Safety Management Standards, Respiratory Protection #42). The decontamination water will be collected for disposal with the remaining liquid waste. Decontamination water and Alconox solution will be collected separately.

9.4.3 Electrical and Mechanical Lockouts

Electrical and/or mechanical lockouts will be required any time during field activities if the need to repair or maintain the remediation equipment arises. Lockouts will include disabling the equipment by interrupting the power source and locking and tagging all movable or hazardous parts and power sources. Refer to the appropriate corporate safety management standard for additional information on lockout/ tagout procedures (Safety Management Standard, Lockout and Tagout Safety #23).

9.5 SAFETY TRAINING

9.5.1 Personnel Training

The Superfund Amendment Reauthorization Act (SARA) passed into law in 1986 requires employers to provide training for employees who are engaged in hazardous materials operations and site cleanups. 29 CFR and CCR Title 8 require 40 hours of initial training and 8 hours of annual refresher training for workers at uncharacterized sites. This will include all workers involved in drilling and well sampling/ testing operations. All other staff are required to have 24 hours of initial training and 8 hours of annual refresher training. Workers who are on site one time only or infrequently are not required to have any training—provided they are continually escorted by trained individuals. Supervisors and managers are required to have 8 hours of specialized training. All site personnel must meet these training requirements in addition to the site-specific training requirements prior to working on site. All employees must have received the required OSHA training per 29 CFR 1910.120. Copies of records of employee training will be immediately available. Refer to 29 CFR 1910.120 for additional information on requirements for personnel training.

Safety training, required of all personnel working on site, will include:

- 40-hour or 24-hour OSHA training and 8-hour OSHA annual refresher (all staff participating in drilling operations will have 40-hour OSHA training).
- Project health and safety kickoff briefing.

- Daily tailgate safety meetings.
- Physical and health effects of the hazardous chemicals.
- How to lessen or prevent exposure to these hazardous chemicals through usage of control, work practices, and PPE.
- Emergency procedures to follow if they are exposed to chemicals.
- Location of the MSDS file and hazardous chemicals list.

The task leader and project safety officer will ensure that all personnel are trained properly and that records are maintained. Copies of MSDSs for all hazardous chemicals known or suspected on site will be maintained in the work area or project trailer. Copies of MSDSs will also be provided to all contractors participating in this effort or whose base activities may be affected by project activities and McClellan AFB Environmental Compliance (SM-ALC/EMPO).

A project health and safety kickoff meeting will be conducted before any personnel begin field work. At the completion of the training, each person will sign the health and safety plan acceptance form (Figure 9-1). There may be instances where it is not practical to give every worker arriving at the site a comprehensive safety briefing. If the worker will be at the site for less than 4 hours, the SSO will be responsible for supervising/escorting the worker while at the site. The worker will be listed as a "casual worker" in the field logbook and will not be required to sign a health and safety plan acceptance form.

9.5.2 Personnel Instruction

All field personnel shall be instructed in basic hazard awareness by the SSO prior to daily field work activities. This training will be augmented by crew briefings and site-specific tasks training. Each daily tail gate safety briefing will include a general safety topic in addition to that day's work. Initial training will include:

- History of the site.
- Chemical hazards.
- Requirements for PPE, its effectiveness, and its limitations.
- Emergency procedures.
- Decontamination procedures.
- Personal hygiene and care.
- General health and safety practices.
- Physical hazards.
- Outline of the days work, potential hazards, and topic of the day.

Information concerning the health and safety hazards of the contaminants at the site shall be maintained at the site by the SSO, and shall be available to the employees for examination.

The SSO shall ensure that all site employees have been trained on the proper fitting, use, care, and limitations of respirators and other PPE that has been provided. Verification of a qualitative respirator fit test shall also be made. No facial hair, which interferes with a satisfactory seal of the respirator to the face, will be allowed on personnel required to wear respiratory protective equipment.

9.6 SITE MONITORING

This exposure monitoring plan describes the air monitoring strategy, the sampling methods and instrumentation to be used, the methods and frequency of calibration, and the action levels for potential work-site hazards. Air monitoring data and instrument calibration will be recorded on appropriate forms. All monitoring records/forms will be maintained in the on-site project file. In addition, one unannounced health and safety audit will be performed during the early portions of the field work.

9.6.1 Air Monitoring

The following program establishes ongoing surveillance to detect air contaminants that could be hazardous to field personnel performing work for this field work. This program will also ensure the continuing accuracy of the work zones and the adequacy of the assigned level of PPE. During field activities, the designated field team member will monitor the work site. Calibration of all monitoring equipment will be performed in accordance with the manufacturer's procedures by trained Radian International instrument technicians or authorized personnel. The project manager and project safety officer will be notified of any contaminant levels that cause a suspension of site activities.

9.6.1.1 Organic Vapor Concentration Measurement

Organic vapor concentrations (OVCs) will be measured with a PID and direct reading detector tubes. Table 9-2 presents the organic vapor sampling scheme.

9.6.1.1.1 Photoionization Detector

Real-time airborne VOC concentrations will be evaluated with a PID when Radian International personnel are participating in soil, sediment, and water investigation activities. The PID will respond to gases and vapors with an ionization potential less than the electron voltage (eV) of the instrument lamp (10.2 eV). A PID will be taken into the field and operated during soil-disturbing activities where contaminated soil or groundwater may be encountered. Air monitoring will be conducted whenever new soil is broken and at least every 30 minutes after that. Air monitoring will also be performed when a well is opened for sampling. Measurements will be made at the borehole, wellhead, and personnel breathing zones (BZs) where activities are being performed. The instrument will be calibrated at the beginning and end of each work day using a known concentration of isobutylene gas. Calibration measurements will be documented and kept in the project file.

All PID measurements will be adjusted with respect to background measurements. For instance, if background PID measurements indicate 2 parts per million (ppm) OVC, and personnel BZ measurements indicate 7 ppm OVC, assume 5 ppm OVC in the BZ resulting from environmental contaminants.

Table 9-2. Hydrocarbon Response Criteria

OVCs and Specific Contaminant Monitoring	Sampling Frequency	Action Taken
OVC 0-<1 ppm for >2 minutes	Whenever new soil is broken, when monitoring well is opened, upon initial approach to surface water and sediment sampling sites, at least every 30 minutes throughout activity.	Continue work with required minimum PPE for the field activity.
OVC 1-10 ppm for >2 minutes • Collect DTs at SS for: — Benzene — TCE — VC DT measurements reveal no detectable concentrations	Every 15 minutes until OVC levels decrease to <1 ppm.	Continue to work with required minimum PPE for the field activity. — All personnel on site will don Tyvek coveralls.
OVC 11-100 ppm for >2 minutes • Collect DTs at SS for: — Benzene — TCE — VC DT measurements at SS reveal: — Benzene ≤10 ppm — TCE ≤10 ppm — VC ≤10 ppm	Every 15 minutes.	— All personnel on site will don half-face or full-face air purifying respirator equipped with organic vapor/HEPA filter cartridges. — All personnel on site will don Tyvek coveralls.
OVC 101-500 ppm >2 minutes • Collect DTs at SS for: — Benzene — TCE — VC DT measurements at SS reveal: — Benzene ≤50 ppm — DCE ≤50 ppm	Every 10 minutes.	— All personnel on site will don full-face air purifying respirator equipped with organic vapor/ HEPA filter cartridges.
OVC >500 ppm or Benzene >50 ppm or TCE >50 ppm or VC >50 ppm	N/A	— Stop work. — Work crews position themselves upwind of site. — Re-evaluate in 15 minutes. — Contact field coordinator and project health and safety officer.

BZ = breathing zone
DCE = dichloroethene
DT = detector tube
HEPA = High Efficiency Particulate Arrestance
HS = headspace
mg/m^3 = milligram per cubic meter
N/A = not applicable
OVC = organic vapor concentration
PID = photoionization detector
PPE = personal protective equipment
ppm = parts per million
SS = sampling site
TCE = trichloroethene
VC = vinyl chloride

9.6.1.1.2 Direct Reading Detector Tubes

A Dräeger detector tube (DT) kit shall be available in each sampling vehicle to determine airborne concentrations of specific contaminants during work activities where the PID is used. Detector tubes will be available for:

- Benzene.
- TCE.
- Vinyl chloride.

These measurements will be collected in the general area and in the worker BZ as a means of speciating airborne concentrations of VOCs as measured by the PID.

Detector tube readings are taken by drawing a known volume of air through a DT and observing a colorimetric indication of airborne concentrations. Contaminant concentrations can be read by observing the portion of the DT that shows a detectable color change and comparing the color to the values marked on the side of the tube. Care should be exercised to use the correct number of compressions of the Dräger pump for the DT being used. Instructions for the proper number of compressions are in each DT package.

Field team members should be aware that actual air contaminant concentrations can vary by 25% from the values displayed by the DTs. When using the Dräeger hand pump, care should be exercised to:

- Completely compress the bellows.
- Allow sufficient time for the bellows to completely expand.
- Use the correct number of compressions (as dictated in the instructions for the detector tubes).

9.6.1.2 Airborne Particulate Concentrations

Personnel are not required to monitor for airborne particulate on a routine basis. However, if field activities begin to generate visible levels of airborne particulate, personnel will be required to don a half-face air-purifying respirator equipped with an organic vapor/HEPA cartridge. If work activities generate prolonged airborne dust concentrations (*i.e.*, 15 minutes), the field coordinator will immediately contact the project health and safety officer and arrange for measurements with a Mini-Ram, real-time, airborne particulate monitor.

9.6.2 Noise-Level Monitoring

Field personnel may be monitored for exposures to noise during field activities using a sound-level meter. The primary activities of concern include, but are not limited to:

- During active drilling operations.

- Generator operation and the proximity of support activities in relation to the primary noise source (diesel exhaust).

- The proximity of aircraft operations.

Noise-level exposure monitoring will be initiated at the request of the SSO with concurrence of the project health and safety officer. The following procedures will be followed:

- Calibrate the sound level meter according to the manufacturer's instructions. Adjust the sound level meter as required. Attach a windscreen as necessary.

- After calibration of the instrument, set the instrument to the A scale and record the noise levels at specific work locations during suspect work activities.

- Noise-level readings will be recorded in a log, noting the scale, response setting, time, date, analyst, type of activity, and individuals potentially exposed. These records will be made part of the permanent project file. If excessive noise levels are detected, the following corrective actions will be taken:

  — Personnel subject to the noise hazard will be required to wear hearing protection;

  — When possible, personnel will be protected from the noise source by a physical barrier that will enclose or deflect the sound waves; and

  — When feasible, personnel will increase their distance from the noise source.

The OSHA permissible exposure limit (PEL) for noise is 90 dBA scale for an eight-hour day. All employees who are exposed to noise levels at or exceeding an action level of 85 dBA are required to participate in a hearing conservation program. The requirements of this program are provided in CFR Title 29, Part 1910.95, paragraphs c-o.

A good rule of thumb for field noise evaluation is that if you cannot communicate in a normal tone of voice at a distance of 3 feet, ambient noise levels are approaching 85 dBA and hearing protection should be worn.

9.6.3 Heat Stress Monitoring

Wearing PPE puts a hazardous waste worker at considerable risk of developing heat stress. Because heat stress is one of the most common and potentially serious illnesses at hazardous waste sites, regular monitoring and other preventive precautions are vital. See Section 9.3.2.4 for the signs and symptoms of heat stress.

Heat stress monitoring will be initiated when temperatures exceed 90°F. Monitoring will be conducted by using one or several of the methods described below:

- For workers wearing permeable clothing (lightweight pants and shirt), follow recommendations for monitoring requirements and suggested work/rest schedules in the current ACGIH *Threshold Limit Value for Heat Stress*. If the actual clothing worn differs from the above

ACGIH standard ensemble in insulation value and/or wind and vapor permeability, change the monitoring requirements and work/rest schedules.

- For workers wearing semipermeable or impermeable encapsulating ensembles, the ACGIH standard cannot be used. For these situations, workers should be monitored when work area temperatures are above 70°F (21°C). To monitor the workers, measure:

  1. **Heart rate.** Count the radial pulse during a 30-second period as early as possible in the rest period. If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same.

  2. **Oral temperature.** Use an electronic clinical thermometer (usually about 15 seconds under the tongue) or similar device to measure the oral temperature at the end of the work period after entering the support zone (SZ) and before drinking:

     — If oral temperature exceeds 99.6°F (37.6°C), shorten the next work cycle by one-third without changing the rest period.

     — If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following work cycle by one-third.

     — Do not permit a worker to wear a semipermeable or impermeable garment when his/her oral temperature exceeds 100.6°F (38.1°C).

  3. **Body water loss, if possible.** Locate the scale in the field office. Measure weight on a scale accurate to ±0.25 pounds at the beginning and end of each work day to see if enough fluids are being taken to prevent dehydration. Weights should be taken while the employee wears similar clothing or, ideally, is nude. The body water loss should not exceed 1.5% total body weight loss in a work day.

Control

Proper training and preventive measures will help avert serious illness and loss of worker productivity. Preventing heat stress is particularly important because once someone suffers from heat stroke or heat exhaustion, that person may be predisposed to additional heat injuries. The following are controls that may be implemented to control heat stress:

- Adjust work schedules:

  — Modify work/rest schedules according to monitoring requirements;

  — Mandate work slowdowns as needed;

  — Rotate personnel: alternate job functions to minimize overstress or overexertion at one task;

  — Add additional personnel to work teams; and

  — Perform work during cooler hours of the day, if possible, or at night if adequate lighting can be provided.

- Provide shelter (air-conditioned, if possible) or shaded areas to protect personnel during rest periods.

- Maintain workers' body fluids at normal levels. Daily fluid intake must approximately equal the amount of daily weight lost. When heavy sweating occurs, encourage the worker to drink more. The following strategies may be useful:

  — Maintain water temperature at 50°F to 60°F (10°C to 15.6°C).

  — Have workers drink 16 ounces (0.5 liters) of fluid (preferably water or dilute drinks) before beginning work.

  — Urge workers to drink a cup or two every 15 to 20 minutes, or at each monitoring break. A total of 1 to 1.6 gallons (4 to 6 liters) of fluid per day are recommended, but more may be necessary to maintain body weight.

  — Weigh workers before and after work to determine if fluid replacement is adequate.

- Encourage workers to maintain an optimal level of physical fitness.

- Train workers to recognize and treat heat stress. As part of training, identify the signs and symptoms of heat stress.

9.7 MEDICAL SURVEILLANCE REQUIREMENTS

All personnel will have records of current medical surveillance physicals on file before starting work on site as required by 29 CFR. No additional medical surveillance will be required unless warranted by exposures recorded during the demonstration period.

9.8 EMERGENCY CONTACTS AND MEDICAL FACILITIES

Each organization participating in this project is responsible for health and safety of its workers while work is conducted at the site. The personnel responsible for health and safety are to summon the following emergency contacts in case of an incident. The McClellan AFB emergency response will be contacted first; other emergency contacts will be notified only if McClellan AFB emergency response does not initiate notification or if on-site emergency contact is unsuccessful. Emergency contacts and medical facilities are listed in Table 9-3. Routes to the medical facilities are shown in Figure 9-2.

To drive to the Watt Avenue Medical Clinic, take Kilzer Avenue to AF Street and turn left. Turn right onto Dudley Avenue, exit the Bell Gate and turn left (south) onto Winters Avenue. Drive approximately 0.75 mile to Interstate 80. Proceed east onto the freeway for approximately 1.5 miles then exit onto Watt Avenue and turn left (heading north). Drive approximately 1.5 miles. The Watt Avenue Medical Clinic is on the right at 5710 Watt Avenue.

To drive to Mercy San Juan Hospital, take Kilzer Avenue to AF Street and turn left. Turn right onto Dudley Avenue, exit the Bell Gate and turn left (south) onto Winters Avenue. Drive approximately 0.75 mile to Interstate 80. Proceed east onto the freeway for approximately 3 miles then exit onto Madison Avenue. Turn right (heading east). Turn left at Auburn Boulevard and drive approximately 2 miles. Turn

Table 9-3. Emergency Contacts List

Emergency Agency	Name/Title	Telephone
Project Health & Safety Officer	Kim Worl, CIH	916/857-7458 (Work) 916/427-3362 (Home)
Police		916.643.6160 After standown or in case of no base emergency response: 911
Fire Response		916.643.4676 After standown or in case of no base emergency response: 911
Ambulance		916.643.4676 After standown or in case of no base emergency response: 911
McClellan AFB Contacts	Jim Lu, Remedial Project Manager Paul Bernheisel, Field Program Manager	916/643-0830 ext. 466 916/643-0830 ext. 474
Urgent Care Facility	Watt Avenue Medical Clinic 5710 Watt Avenue North Highlands, CA 95660	916/344-8866
Hospital	Mercy-San Juan Hospital 6501 Coyle Avenue Carmichael, CA 95608	916/537-5000
Medical Emergency 24-Hour Toxicological Information Service		513/421-3063
EPA-ERT Emergency		201/321-6660
Center for Disease Control		414/639-3311
CHEMTREC		800/424-9300
Closest Radian Office	Sacramento	916/362-5330

AFB = Air Force Base
CIH = certified industrial hygienist
EPA-ERT = U.S. Environmental Protection Agency – Emergency Response Team

right onto Greenback, then right onto Parkoaks, and then right onto Coyle Avenue. Mercy San Juan Hospital is on the left at 6501 Coyle Avenue, Carmichael.

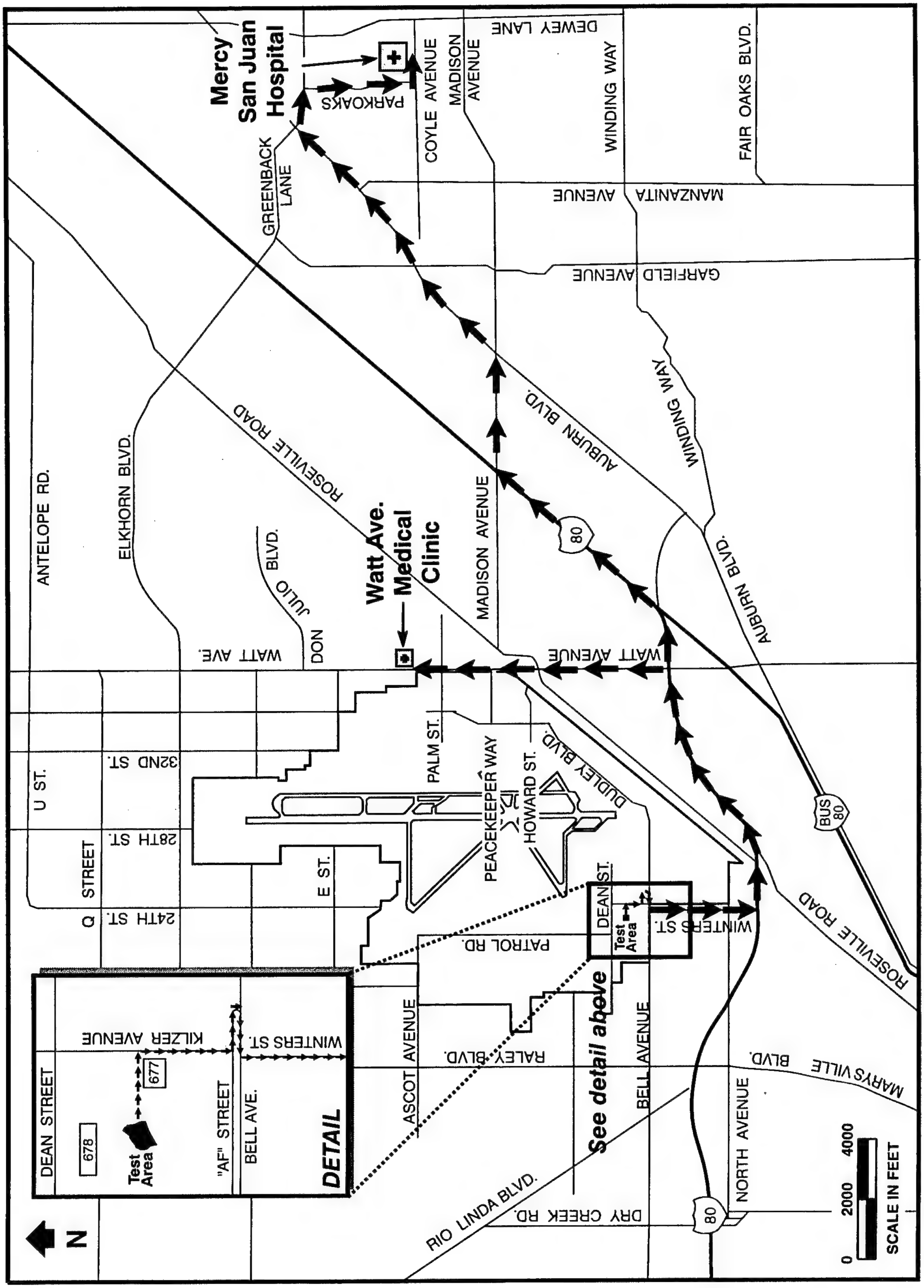

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Figure 9-2. Transportation Routes to Medical Care Facilities

10.0 TECHNICAL EVALUATION REPORT

A Technology Applicable Analysis Report (TAAR) will be prepared and submitted to document the results of this project. The report will include the following key sections:

1.0 EXECUTIVE SUMMARY
- 1.1 Background
- 1.2 Demonstration Description
- 1.3 Results
- 1.4 Conclusions
- 1.5 Recommendations

2.0 INTRODUCTION AND BACKGROUND
- 2.1 SERDP NETTS
- 2.2 Technology Objectives
- 2.3 Technology Overview
- 2.4 Demonstration Scope
- 2.5 Document Organization

3.0 SITE DESCRIPTIONS
- 3.1 Location and Setting
- 3.2 Geology
- 3.3 Hydrogeology
- 3.4 Contaminant Distribution

4.0 DEMONSTRATION DESCRIPTION
- 4.1 Technology Principles
- 4.2 Treatment System Installation and Operation
- 4.3 The [number] Phases of the Technology Demonstration
- 4.4 Sampling Strategy and QA/QC Results

5.0 TECHNOLOGY PERFORMANCE EVALUATION
- 5.1 Performance Data
- 5.2 Remediation Efficiency
- 5.3 Process Flow Efficiency

6.0 OTHER TECHNOLOGY ISSUES
- 6.1 Environmental Regulatory Requirements
- 6.2 Personnel Health and Safety
- 6.3 Community Acceptance

7.0 COST ANALYSIS
- 7.1 Basis of Cost Analysis
- 7.2 Cost Categories
- 7.3 Results of Cost Analysis

8.0 RECOMMENDATIONS

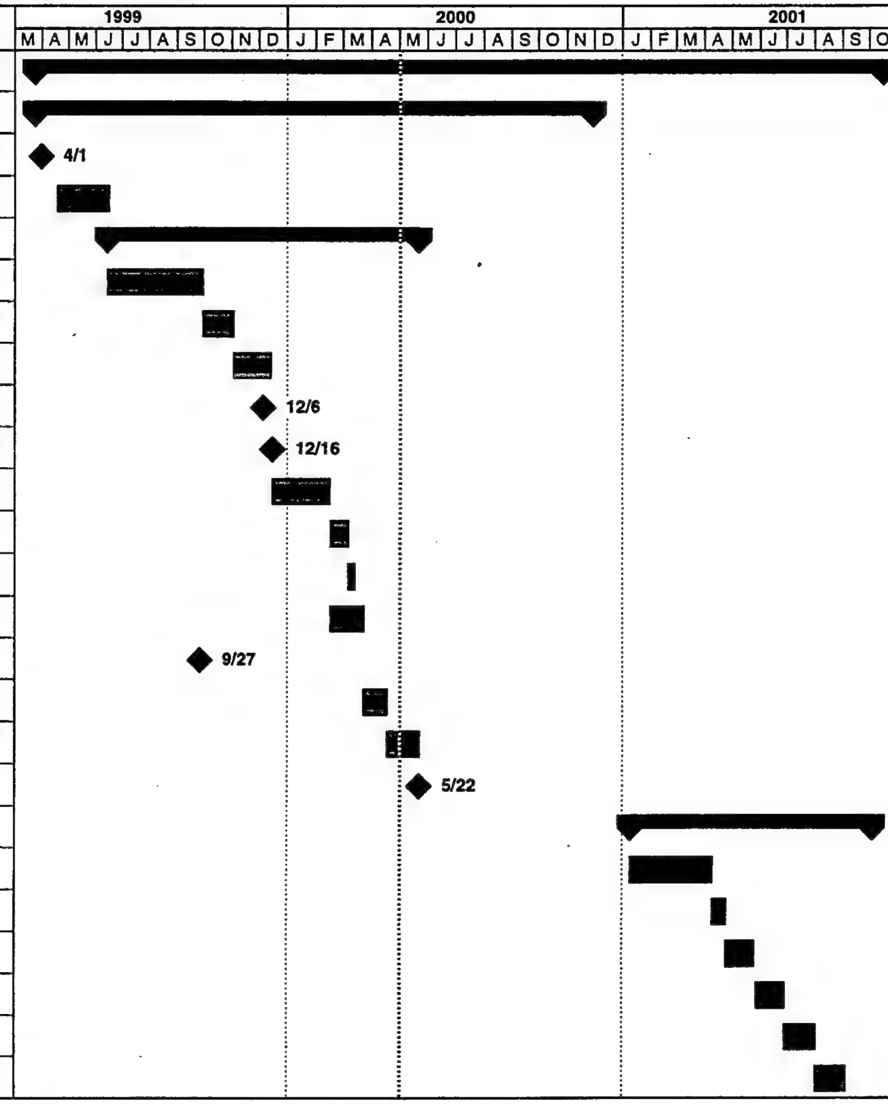
11.0 SCHEDULE

This section presents the current schedule for implementing project activities.

Figure 11-1 presents the schedule of planned activities for the pre-demonstration, demonstration, demobilization, data analysis, and reporting periods. As shown on Figure 11-1, the anticipated start date of the field activities is 30 May 2000 and the scheduled end date of field activities is 2 January 2001.

Radian International
Aggressive Remediation of VOC Contamination
F04699-97-D-0022 / DO 2011

ID	Task Name	Dur	Start	Finish	%
1	**DO 2011 - Aggressive Remediation**	**651 d**	**3/25/99**	**10/16/01**	**39%**
2	**Period of Performance**	**428 d**	**3/25/99**	**11/30/00**	**0%**
5	Post Award/Kickoff Meeting	1 d	4/1/99	4/1/99	100%
6	T-44 Site-specific conceptual model	41 d	4/19/99	6/15/99	100%
7	**Work Implementation Plan (WIP)**	**239 d**	**6/15/99**	**5/22/00**	**97%**
8	Prepare Working Copy	107 ed	6/15/99	9/30/99	100%
9	McAFB Review	24 d	9/30/99	11/2/99	100%
10	Prepare Draft Copy	27 d	11/3/99	12/13/99	100%
11	Submit Advance Draft Copy	0 d	12/6/99	12/6/99	100%
12	Submit Draft Copy	0 d	12/16/99	12/16/99	100%
13	McAFB/Agency Review	62 ed	12/16/99	2/16/00	100%
14	Prepare Response to Comments Table (RTC)	13 d	2/17/00	3/6/00	100%
15	McAFB review of RTC	5 d	3/7/00	3/13/00	100%
16	Prepare Draft-Final Copy	26 d	2/17/00	3/23/00	100%
17	Submit Draft Final	0 d	9/27/99	3/23/00	100%
18	McAFB/Agency Review	18 d	3/23/00	4/17/00	100%
19	Prepare Final Copy	25 d	4/18/00	5/22/00	32%
20	Submit Final Copy	0 d	5/22/00	5/22/00	0%
21	**Design Drawings and Documents**	**189 d**	**1/10/01**	**10/4/01**	**0%**
22	Prepare Working Copy	90 ed	1/10/01	4/10/01	0%
23	McAFB Review	11 d	4/10/01	4/24/01	0%
24	Prepare Draft Copy	23 d	4/25/01	5/25/01	0%
25	McAFB/Agency Review	23 d	5/29/01	6/28/01	0%
26	Prepare Draft Final Copy	23 d	6/29/01	8/1/01	0%
27	McAFB/Agency Review	23 d	8/2/01	9/4/01	0%



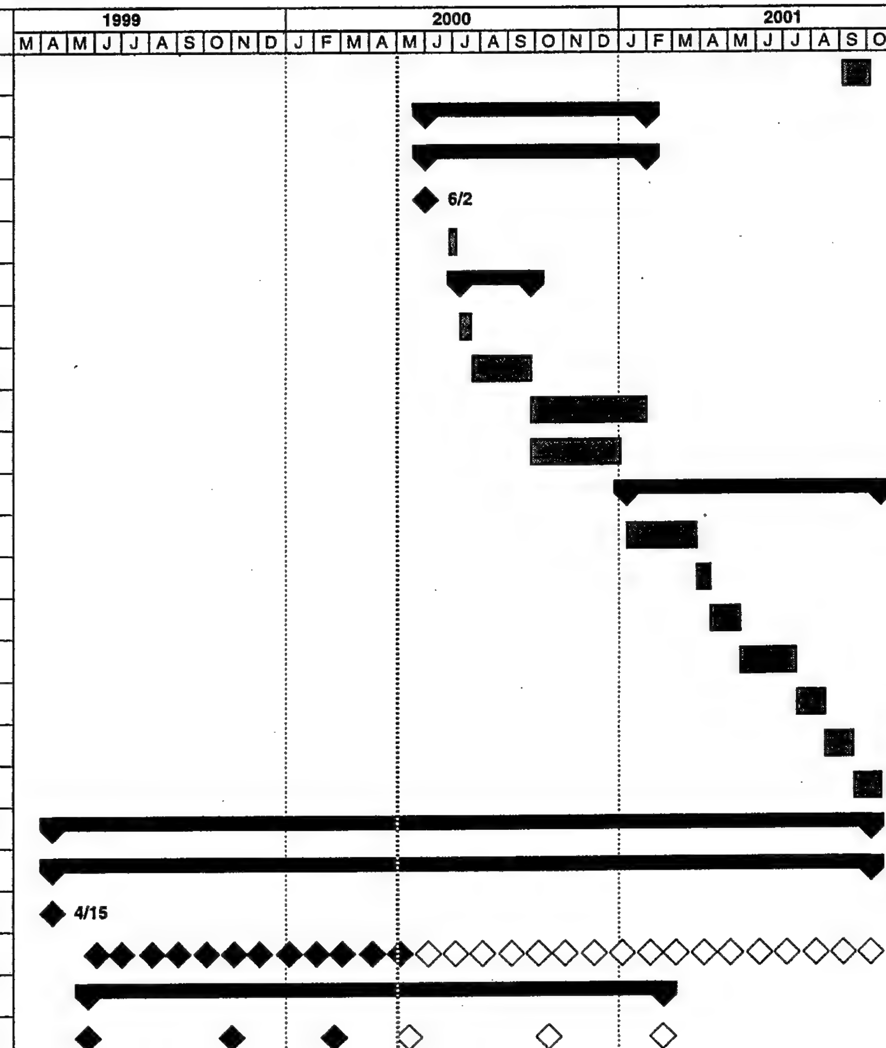
Project: 602311
Date: 5/18/00

Task	Summary	Rolled Up Progress	Split
Progress	Rolled Up Task	External Tasks	Rolled Up Split
Milestone	Rolled Up Milestone	Project Summary	

Pag

Radian International
Aggressive Remediation of VOC Contamination
F04699-97-D-0022 / DO 2011

ID	Task Name	Dur	Start	Finish	%
28	Prepare Final Copy	22 d	9/5/01	10/4/01	0%
29	**Field Work**	**167 d**	**6/2/00**	**1/31/01**	0%
30	**Aggressive Dewatering & Oxidation Testing**	**167 d**	**6/2/00**	**1/31/01**	0%
31	30 Field Notification	1 d	6/2/00	6/2/00	0%
32	Field Preparation/Mobilization	5 d	6/28/00	7/5/00	0%
33	**Data Gap/Aquifer Tests**	**56 d**	**7/10/00**	**9/26/00**	0%
34	Installation and Develop	10 d	7/10/00	7/21/00	0%
35	Tests	46 d	7/24/00	9/26/00	0%
36	Modeling	86 d	9/27/00	1/31/01	0%
37	Peroxide Testing	65 d	9/27/00	1/2/01	0%
38	**Technology Application Analysis Report (TAAR)**	**197 d**	**1/10/01**	**10/16/01**	0%
39	Prepare Working Copy	55 d	1/10/01	3/27/01	0%
40	McAFB Review	11 d	3/28/01	4/11/01	0%
41	Prepare Draft Copy	23 d	4/12/01	5/14/01	0%
42	McAFB/Agency Review	61 ed	5/14/01	7/14/01	0%
43	Prepare Draft-Final Copy	23 d	7/16/01	8/15/01	0%
44	McAFB/Agency Review	31 ed	8/15/01	9/15/01	0%
45	Prepare Final Copy	22 d	9/17/01	10/16/01	0%
46	**Delivery Order Management**	**629 d**	**4/15/99**	**10/5/01**	43%
47	**Engineering Network Analysis**	**629 d**	**4/15/99**	**10/5/01**	41%
48	Intial ENA	0 d	4/15/99	4/15/99	100%
49	Monthly ENA Updates	594 d	6/4/99	10/5/01	41%
80	**Meetings**	**440 d**	**5/25/99**	**2/19/01**	50%
81	Program Status Meetings	440 d	5/25/99	2/19/01	50%



Project: 602311
Date: 5/18/00

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress | External Tasks | Project Summary | Split | Rolled Up Split

12.0 MANAGEMENT AND STAFFING

This section presents the organizational structure of the management of the technology demonstration and the names and qualifications of all key personnel involved.

12.1 DEMONSTRATION MANAGEMENT PERSONNEL

All work will be conducted by Radian International under the oversight of the McClellan AFB EM. The following are the key McClellan AFB EM personnel and their respective responsibilities:

Paul Sears	Contracting Officer
Jim Lu	Project Manager, Contract Project Manager
Paul Bernhiesel	Field Team Representative
Tim Chapman	NETTS Support Contractor

12.2 RADIAN INTERNATIONAL RESPONSIBILITIES AND QUALIFICATIONS

Radian International will prepare all work plans and reports, provide technical oversight, and data analysis and interpretation for the evaluation of the aggressive remediation strategy. Radian International will be responsible for the field activities, laboratory analyses, and data validation. Key staff from Radian International assigned to the field investigation will share the responsibility. Key personnel are identified below:

Deena Stanley	Project Manager/Supervisor (POC1)
Joy Rogalla	Project QA Manager (POC2)
Kim Worl	Project Health and Safety Officer (HSO)
TBD*	Site Health and Safety Officer (SSO)
Joy Rogalla	Data Validation Manager
Elise Willmeth	Task Leader

* The HSO will assign appropriate staff to serve as SSO during specific field activities. These assignments will be noted in the appropriate field log notebook.

12.3 SUBCONTRACTORS

Subcontractors needed for project activities will be organized by Radian International. A drilling company will be contracted for the installation of groundwater wells and piezometers. TerraVac will be contracted to conduct the *in situ* oxidation effort. One or more California-certified laboratories will be contracted to analyze samples collected that are not designated for field evaluation.

13.0 REFERENCES

Anderson, Mary P., and Woessner, William W., 1992. *Applied Groundwater Modeling Simulation of Flow and Advective Transport*. Academic Press, Inc., Harcourt Brace Jonaovich, Publishers.

Benson, 1991. *User's Manual to Vent2D: A Multi-Compound Vapor Transport and Phase Distribution Model.*

California Department of Water Resources (CDWR), 1974. *Evaluation of Groundwater Resources*. Sacramento County Bulletin 118-3.

CDWR, 1978. *Evaluation of Groundwater Resources of Sacramento Valley*. Sacramento County Bulletin 118-6.

CH2M HILL, 1994. *Groundwater Remedial Investigation/Feasibility Study Report*. Prepared for McClellan AFB, Sacramento, California.

CH2M HILL, 1997. *Groundwater Operable Unit (GWOU) Phase 2 Work Plan, Volume 1*. Final. August.

CH2M HILL, 1999. *Basewide VOC Feasibility Study Report*. Final. December.

Chapman, T. E., 1999. *Intrinsic Remediation of Halogenated Hydrocarbons in Groundwater*. California State University, Sacramento.

Engineering Science, 1983. *Final Report, Installation Restoration Program, Phase II-Confirmation*. Prepared for U.S. Air Force Occupational and Environmental Health Laboratory, Brooks AFB, Texas.

Kruseman, G.P., and N.A. de Ridder, 1991. *Analysis and Evaluation of Pumping Test Data*. International Institute for Land Reclamation and Improvement, The Netherlands. Second Edition.

Lewis, R.J., 1997. *Hazardous Chemicals Desk Reference*.

Lin, et al., 1997. *FEMWATER: A Three-Dimensional Finite Element Computer Model for Simulating Density-Dependent Flow and Transport in Variably Saturated Media*. Technical Report CHL-97-12. July.

McClellan AFB EMR, 1993. *Soils Management Manual*, Version 1.0.

Norris, R.M., 1990. *Geology of California*. Second Edition.

OHM, 1997. *Sampling and Analysis Plan, Groundwater Treatment Facilities, McClellan Air Force Base, California*. Draft. February.

Pankow, James F. and John A. Cherry, 1996. *Dense Chlorinated Solvents and Other DNAPLs in Groundwater*. Waterloo Press.

Radian Corporation, 1986. *Installation Restoration Program Sampling and Analysis Program: Technical Reports*. Prepared for McClellan AFB, Sacramento, California.

Radian Corporation, 1990. *Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) Sampling and Analysis Plan*. February.

Radian Corporation, 1991. *Preliminary Groundwater Operable Unit Remedial Investigation Technical Report*. Prepared for McClellan AFB, Sacramento, California.

Radian Corporation, 1992. *Preliminary Groundwater Operable Unit Remedial Investigation*. Final. September.

Radian Corporation, 1995. *Interim Basewide Remedial Investigation Report Part 2B – Operable Unit B Remedial Investigation Characterization Summaries*. Final. December.

Radian Corporation, 1996. *Dual-Phase Extraction Treatability Study Work Plan*. Final. July.

Radian International, 1997. *Remedial Investigation General Framework Report*. Final.

Radian International, 1998a. *Groundwater Monitoring Program Quarterly Report. Second Quarter 1998*. Final. September.

Radian International, 1998b. *McClellan Air Force Base Data Gap Field Sampling Plans – 2*. Final. September.

Radian International, 1999a. *Groundwater Monitoring Program Quarterly Report, First Quarter 1999*. Final. June.

Radian International, 1999b. *Groundwater Monitoring Program Quarterly Report, Fourth Quarter 1998*. Final. April.

Radian International, 1999c. *Basewide RI/FS QAPP Update, Revision 4*. Final. June.

Sacramento-Air Logistics Command (SM-ALC), 1996. McAFB Instruction 32-2, 1996. Hazardous Waste Management Plan.

TerraVac, 1995. *OxyVac®. Available online at: http//www.terravac.com/toolsolv.htm*. November.

URS Greiner Woodward-Clyde Federal Services Inc., 1999. *Engineering Evaluation and Cost Analysis for Soil Vapor Extraction, IC 5*. Draft Final. August.

U.S. EPA, 1994. *Guidance for the Data Quality Objectives Process*. EPA QA/G-4.

U.S. EPA, 1996. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods – SW846*. Third Edition, Update III.

APPENDIX A

Well Construction Details and Lithologic Data

Well Construction Details

Well Name: MW-451
(Permanent Well Name)

Supervised by: D. Perry

Well Type: EXW VAP VEW MNW OBS PZ TST Other: ________
(Circle only one choice)

Location Description: West of Building 668

Boring Number
MWDI

Installation Date
2-5-99

Boring Company
Water Development

Construction Method
Air Rotary Casing Hamma

Drilling Method (if different)

Owner:
USAF

Owner's Address
McClellan AFB

Owner's Telephone:
(916) 643-0830

Survey Data

Northing

Easting

Units for Coordinates

Coordinate System

Measuring Point Elevation

Survey Company

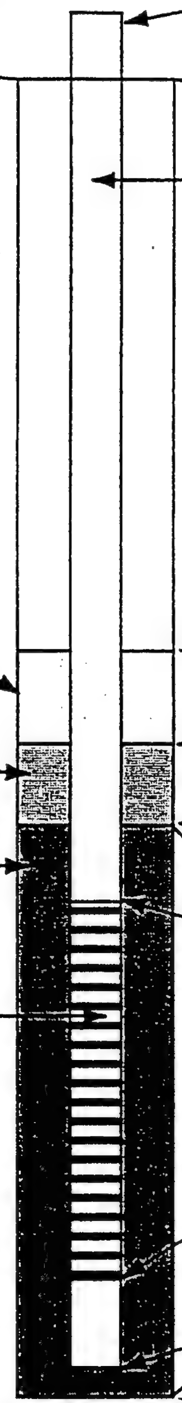
Survey Date

Installation IC 5

Project GWOU PH 2

Location Proximity Inside
(Inside or Outside Facility)

Geohydrologic Zone:
- ☐ Aquifer
- ☐ Confining Layer or Aquiclude
- ☒ Lower or Confined Aquifer
- ☐ Perched Aquifer
- ☐ Unsaturated Zone
- ☐ Water Table Aquifer



Surface Completion Type

Type/Amount of Grout
Gallons of Water
720

Sacks of Cement
90

Pound of Bentonite
450 lbs

Type/Amount of Bentonite Seal
1-5 gallon Bucket
3/8 in coated bentonite pellets

Type/Amount of Sand Bridge
1-100 lb sack of #60 RMC Lonestar Sand

Type/Amount of Sand Pack
21-100 lb ~~sand~~ sack of #3 RMC Lonestar

Screen Type and Length
10 Ft S.S wire wrap screen

Screen Slot size
0.02 in

Screen Diameter
5 in

Screen Percent Open

Screen Material
S.S

Borehole Diameter
10 in

Measuring Point Location (i.e. TOC)

Ground Surface Elevation

Well Details
Casing Type
Sch 80 PVC

and Amount
310 Ft

Casing Diameter
5 in

Centralizer Spacing
Every 40 Feet / Top & Bottom of screen

and Number Used
9

Top of Bentonite Seal
302.5 Ft

Top of Sand Bridge
305 Ft

Top of Sand Pack
307 Ft

Top of Screen
310

Filter Pack Length
13

Bottom of Screen
320

Total Well Casing Depth
320

Borehole Depth
325

Lithologic Log

Installation: IC 5 Project: GWOU PH2

Location: west of 668 Boring Number: MW-01 Date: 2-4-99 Geologist: D. Perry

Starting Depth								
1	Main Mod:	Gravelly	Sandy	Silty	Clayey	Pred Lith:	Gravel Clay Sand Silt	
	Minor / Trace	Gravel	Sand	Silt	Clay			
	Color:	Yellowish Brown	Munsell:	10YR 5/6		Grain Size:	VF: 50 F: 50 M: C: VC:	
	Grading:	Well	Moderate	Poor	Gap	Roundness	Ang Rndd Sbrndd Subang	
	Minerals (%):	Qtz:	Mafic:	Volc:	Gran:	FSPR:	Mica:	
	2nd Porosity:	Yes No	Hardpan	Yes No		Moisture:	Dry Sat Damp Moist Wet	
Ending Depth 10	USCS:	GW GP GM GC SW SP SM SC ML CL OL MH CH OH						
	Lynx Code:	H H H H H H H M M M L M L - L L -						
	Observations:							

Starting Depth								
10	Main Mod:	Gravelly	Sandy	Silty	Clayey	Pred Lith:	Gravel Clay Sand Silt	
	Minor / Trace	Gravel	Sand	Silt	Clay			
	Color:	Dark Grayish Brown	Munsell:	10YR 4/2		Grain Size:	VF: F: M: C: VC:	
	Grading:	Well	Moderate	Poor	Gap	Roundness	Ang Rndd Sbrndd Subang	
	Minerals (%):	Qtz: 85	Mafic: 5	Volc:	Gran:	FSPR: 10	Mica:	
	2nd Porosity:	Yes No	Hardpan	Yes No		Moisture:	Dry Sat Damp Moist Wet	
Ending Depth 35	USCS:	GW GP GM GC SW SP SM SC ML CL OL MH CH OH						
	Lynx Code:	H H H H H H H M M M L M L - L L -						
	Observations:							

Starting Depth								
35	Main Mod:	Gravelly	Sandy	Silty	Clayey	Pred Lith:	Gravel Clay Sand Silt	
	Minor / Trace	Gravel	Sand	Silt	Clay			
	Color:	yellowish Brown	Munsell:	10YR 5/4		Grain Size:	VF: F: M: C: VC:	
	Grading:	Well	Moderate	Poor	Gap	Roundness	Ang Rndd Sbrndd Subang	
	Minerals (%):	Qtz:	Mafic:	Volc:	Gran:	FSPR:	Mica:	
	2nd Porosity:	Yes No	Hardpan	Yes No		Moisture:	Dry Sat Damp Moist Wet	
Ending Depth 42	USCS:	GW GP GM GC SW SP SM SC ML CL OL MH CH OH						
	Lynx Code:	H H H H H H H M M M L M L - L L						
	Observations:							

Lithologic Log

Installation: ICS Project: GWOU PH2

Location: West of 668 Boring Number: MW-01 Date: Geologist: D. Perry

Starting Depth 42 / Ending Depth 62																
Main Mod:	Gravelly	Sandy	Silty	Clayey	Pred Lith:	Gravel	Sand	Silt	Clay							
Minor / Trace	Gravel	Sand	Silt	Clay												
Color:	Brown	Munsell:	7.5YR 4/4		Grain Size:	VF:	F:	M:	C:	VC:						
Grading:	Well	Moderate	Poor	Gap	Roundness	Ang	Rndd	Sbrndd	Subang							
Minerals (%):	Qtz: 85	Mafic: 10	Volc: Trace	Gran:	FSPR: 5	Mica: Trace										
2nd Porosity:	Yes	No	Hardpan	Yes	No	Moisture:	Dry	Damp	Moist	Wet	Sat					
USCS:	GW	GP	GM	GC	SW	SP	SM		SC	ML		CL		OL	MH	CH
Lynx Code:	H	H	H	H	H	H	H	M	M	M	L	M	L	-	L	L
Observations:																

Starting Depth 62 / Ending Depth 72																
Main Mod:	Gravelly	Sandy	Silty	Clayey	Pred Lith:	Gravel	Sand	Silt	Clay							
Minor / Trace	Gravel	Sand	Silt	Clay												
Color:	Yellowish Brown	Munsell:	10YR 5/4		Grain Size:	VF:	F:	M:	C: 50							
Grading:	Well	Moderate	Poor	Gap	Roundness	Ang	Rndd	Sbrndd	Subang							
Minerals (%):	Qtz: 70	Mafic: ~~10~~ 15	Volc: 5	Gran:	FSPR: 10	Mica:										
2nd Porosity:	Yes	No	Hardpan	Yes	No	Moisture:	Dry	Damp	Moist	Wet	Sat					
USCS:	GW	GP	GM	GC	SW	SP	SM		SC	ML		CL		OL	MH	CH
Lynx Code:	H	H	H	H	H	H	H	M	M	M	L	M	L	-	L	L
Observations:																

Starting Depth 72 / Ending Depth 102																
Main Mod:	Gravelly	Sandy	Silty	Clayey	Pred Lith:	Gravel	Sand	Silt	Clay							
Minor / Trace	Gravel	Sand	Silt	Clay												
Color:	Dark Reddish Brown	Munsell:	2.5YR 3/4		Grain Size:	VF 50	F: 50	M:	C:	VC:						
Grading:	Well	Moderate	Poor	Gap	Roundness	Ang	Rndd	Sbrndd	Subang							
Minerals (%):	Qtz:	Mafic:	Volc:	Gran:	FSPR:	Mica:										
2nd Porosity:	Yes	No	Hardpan	Yes	No	Moisture:	Dry	Damp	Moist	Wet	Sat					
USCS:	GW	GP	GM	GC	SW	SP	SM		SC	ML		CL		OL	MH	CH
Lynx Code:	H	H	H	H	H	H	H	M	M	M	L	M	L	-	L	L
Observations:																

Lithologic Log

Installation: ICS   Project: GWOU

Location: West of 668   Boring Number: MW-D1   Date: 2-4-99   Geologist: D. Perry

Starting Depth 102	Main Mod:	Gravelly Sandy Silty Clayey
	Pred Lith:	Gravel Clay Sand Silt
	Minor / Trace:	Gravel Sand Silt Clay
	Color:	Yellowish Brown
	Munsell:	10YR 5/4
	Grain Size:	VF: F: M: C: VC:
	Grading:	Well Moderate Poor Gap
	Roundness:	Ang Rndd Sbrndd Subang
	Minerals (%):	Qtz: 80 Mafic: 15 Volc: Trace Gran: FSPR: 5 Mica:
	2nd Porosity:	Yes No
	Hardpan:	Yes No
	Moisture:	Dry Sat Damp Moist Wet
Ending Depth 112	Observations:	

USCS:	GW	GP	GM	GC	SW	SP	SM	SC	ML	CL	OL	MH	CH	OH
Lynx Code:	H	H	H	H	H	H	H M	M	M L	M L	-	L	L	-

Starting Depth 112	Main Mod:	Gravelly Sandy Silty Clayey
	Pred Lith:	Gravel Clay Sand Silt
	Minor / Trace:	Gravel Sand Silt Clay
	Color:	Yellowish Brown
	Munsell:	10YR 5/4
	Grain Size:	VF: F: M: C: VC:
	Grading:	Well Moderate Poor Gap
	Roundness:	Ang Rndd Sbrndd Subang
	Minerals (%):	Qtz: Mafic: Volc: Gran: FSPR: Mica:
	2nd Porosity:	Yes No
	Hardpan:	Yes No
	Moisture:	Dry Sat Damp Moist Wet
Ending Depth 137	Observations:	water table at ~ 117' BGS

USCS:	GW	GP	GM	GC	SW	SP	SM	SC	ML	CL	OL	MH	CH	OH
Lynx Code:	H	H	H	H	H	H	H M	M	M L	M L	-	L	L	-

Starting Depth 137	Main Mod:	Gravelly Sandy Silty Clayey
	Pred Lith:	Gravel Clay Sand Silt
	Minor / Trace:	Gravel Sand Silt Clay
	Color:	Red
	Munsell:	2.5YR 4/6
	Grain Size:	VF: F: M: C: VC:
	Grading:	Well Moderate Poor Gap
	Roundness:	Ang Rndd Sbrndd Subang
	Minerals (%):	Qtz: 85 Mafic: 10 Volc: Gran: FSPR: 5 Mica:
	2nd Porosity:	Yes No
	Hardpan:	Yes No
	Moisture:	Dry Sat Damp Moist Wet
Ending Depth 157	Observations:	

USCS:	GW	GP	GM	GC	SW	SP	SM	SC	ML	CL	OL	MH	CH	OH
Lynx Code:	H	H	H	H	H	H	H M	M	M L	M L	-	L	L	

Lithologic Log

Page 4 of 5

Installation: ICS Project: GWOU PH2

Location: West of 668 Boring Number: MW01 Date: 2-4-99 Geologist: David Par

Starting Depth: 157 — **Ending Depth:** 200

Main Mod:	Gravelly	Sandy	Silty	Clayey					Pred Lith:	Gravel	Sand	Silt	Clay				
Minor / Trace	Gravel	Sand	Silt	Clay													
Color:	Very pale Brown		Munsell:	10YR 7/4					Grain Size:	VF	F:	M:	C:	VC:			
Grading:	Well	Moderate	Poor	Gap					Roundness	Ang	Rndd	Sbrndd	Subang				
Minerals (%):	Qtz:	Mafic:	Volc:	Gran:	FSPR:	Mica:											
2nd Porosity:	Yes	No	Hardpan	Yes	No	Moisture:	Dry	Sat	Damp	Moist	Wet						
USCS:	GW	GP	GM	GC	SW	SP	SM		SC	ML		CL		OL	MH	CH	OH
Lynx Code:	H	H	H	H	H	H	H	M	M	M	L	M	L	-	L	L	-
Observations:																	

Starting Depth: 200 — **Ending Depth:** ~~207~~ 232

Main Mod:	Gravelly	Sandy	Silty	Clayey					Pred Lith:	Gravel	Sand	Silt	Clay				
Minor / Trace	Gravel	Sand	Silt	Clay													
Color:	Dark Yellowish Brown		Munsell:	10YR 4/4					Grain Size:	VF:	F:	M 50	C: 50	VC:			
Grading:	Well	Moderate	Poor	Gap					Roundness	Ang	Rndd	Sbrndd	Subang				
Minerals (%):	Qtz: 80	Mafic: 5	Volc:	Gran:	FSPR: 15	Mica: 5											
2nd Porosity:	Yes	No	Hardpan	Yes	No	Moisture:	Dry	Sat	Damp	Moist	Wet						
USCS:	GW	GP	GM	GC	SW	SP	SM		SC	ML		CL		OL	MH	CH	OH
Lynx Code:	H	H	H	H	H	H	H	M	M	M	L	M	L	-	L	L	-
Observations:																	

Starting Depth: 232 — **Ending Depth:** ~~305~~ 245

Main Mod:	Gravelly	Sandy	Silty	Clayey					Pred Lith:	Gravel	Sand	Silt	Clay				
Minor / Trace	Gravel	Sand	Silt	Clay													
Color:	reddish Brown		Munsell:	2.5YR 4/4					Grain Size:	VF:	F:	M:	C:	VC:			
Grading:	Well	Moderate	Poor	Gap					Roundness	Ang	Rndd	Sbrndd	Subang				
Minerals (%):	Qtz:	Mafic:	Volc:	Gran:	FSPR:	Mica:											
2nd Porosity:	Yes	No	Hardpan	Yes	No	Moisture:	Dry	Sat	Damp	Moist	Wet						
USCS:	GW	GP	GM	GC	SW	SP	SM		SC	ML		CL		OL	MH	CH	
Lynx Code:	H	H	H	H	H	H	H	M	M	M	L	M	L	-	L	L	
Observations:																	

Lithologic Log

Installation: ICS Project: GWOU PH2

Location: west of 668 Boring Number: MW D1 Date: 2-4-99 Geologist: O. Perry

Starting Depth 245	Main Mod:	Gravelly	Sandy	Silty	Clayey			Pred Lith:	Gravel	Sand	Silt	Clay						
	Minor / Trace	Gravel	Sand	Silt	Clay													
	Color:	Yellowish Red		Munsell:	5YR 5/6			Grain Size:	VF:	F:	M:	C: 50	VC: 50					
	Grading:	Well	Moderate	Poor	Gap			Roundness	Ang	Rndd	Sbrndd	Subang						
	Minerals (%):	Qtz: 90	Mafic: 5	Volc:	Gran:			FSPR: 5	Mica:									
	2nd Porosity:	Yes	No	Hardpan	Yes	No		Moisture:	Dry	Damp	Moist	Wet	Sat					
Ending Depth 315	USCS:	GW	GP	GM	GC	SW	SP	SM		SC	ML		CL		OL	MH	CH	OH
	Lynx Code:	H	H	H	H	H	H	H	M	M	M	L	M	L	-	L	L	-
	Observations:																	

Starting Depth 315	Main Mod:	Gravelly	Sandy	Silty	Clayey			Pred Lith:	Gravel	Sand	Silt	Clay						
	Minor / Trace	Gravel	Sand	Silt	Clay													
	Color:	Dark Reddish gray		Munsell:	5YR 4/2			Grain Size:	VF:	F:	M:	C:	VC:					
	Grading:	Well	Moderate	Poor	Gap			Roundness	Ang	Rndd	Sbrndd	Subang						
	Minerals (%):	Qtz: 70	Mafic: 5	Volc: 5	Gran:			FSPR: 5	Mica: 15									
	2nd Porosity:	Yes	No	Hardpan	Yes	No		Moisture:	Dry	Damp	Moist	Wet	Sat					
Ending Depth 325	USCS:	GW	GP	GM	GC	SW	SP	SM		SC	ML		CL		OL	MH	CH	OH
	Lynx Code:	H	H	H	H	H	H	H	M	M	M	L	M	L	-	L	L	-
	Observations:																	

Starting Depth	Main Mod:	Gravelly	Sandy	Silty	Clayey			Pred Lith:	Gravel	Sand	Silt	Clay						
	Minor / Trace	Gravel	Sand	Silt	Clay													
	Color:			Munsell:				Grain Size:	VF:	F:	M:	C:	VC:					
	Grading:	Well	Moderate	Poor	Gap			Roundness	Ang	Rndd	Sbrndd	Subang						
	Minerals (%):	Qtz:	Mafic:	Volc:	Gran:			FSPR:	Mica:									
	2nd Porosity:	Yes	No	Hardpan	Yes	No		Moisture:	Dry	Damp	Moist	Wet	Sat					
Ending Depth	USCS:	GW	GP	GM	GC	SW	SP	SM		SC	ML		CL		OL	MH	CH	OH
	Lynx Code:	H	H	H	H	H	H	H	M	M	M	L	M	L	-	L	L	
	Observations:																	

LOG OF DRILLING OPERATIONS

Boring No. MW-D1

Page 1 of 16

PROJECT GWOU PH 2 LOCATION ·IC5

TOTAL DEPTH 323 START DATE 2-4-99 FINISH DATE 2/4/99

GEOLOGIST David Perry INSTRUMENT/UNITS Feet

DRILLING COMPANY Water Develop LICENSE #: ______ DRILLER Keith Jacobs

DRILLING METHOD Air Rotary Casing Hammer RIG TYPE Speedstar

DRILL BIT TYPE AND SIZE

BORING LOCATION (Street Address or Description) West of 668

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
0							Hand Auger to 5 Feet with no obstructions	Fill	0
2									
4									
							Yellowish Brown silty Sand Very Fine to Fine grain	SM	
6									
8									
				0.5/0		0755			
10									
12							Dark Grayish Brown medium grain Sand		
14								SP	
16									
18									
20				0.2/0		0757			

LOG OF DRILLING OPERATIONS

Boring No. MW01

Page 2 of 16

START DATE 2-4-99 GEOLOGIST David Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
20									
22									
24									
26								SP	
28									
30				0.2/0		0807			
32									
34									
36							yellowish Brown clay Hard pan	CL	
38									
40				0.2/0		0808			

LOG OF DRILLING OPERATIONS

Boring No. MW-OP

START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
40									
42								CL	
44									
46									
48							Brown Medium Grain Poorly graded Sand.	SP	
50				0.1/0		0817			
52									
54									
56									
58									
60				0/0		0818			

LOG OF DRILLING OPERATIONS

Boring No. MW-~~??~~ D1

START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
80									
82									
84									
86									
88									
90				2.0/0		0850		SM	
92									
94									
96									
98									
100				1.9/0		0852			

LOG OF DRILLING OPERATIONS

Boring No. MW-D1 ~~MW-D3~~

Page 4 of 16

START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
60									
62								SP	
64									
66							Yellowish Brown coarse grained poorly graded Sand	SP	
68									
70				0.5/0		0831			
72									
74							Dark Reddish Brown silty Sand	SM	
76									
78									
80				0.9/0		0834			

LOG OF DRILLING OPERATIONS

Boring No. MW-~~03~~ DL

START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
100									
102								SM	
104									
106							Medium Grained Sand	SP	
108									
110				0.9/0		0905			
112									
114							Yellowish Brown silty sand	SM	
116							▽ water level		
118									
120				1.8/0		0909			

LOG OF DRILLING OPERATIONS

Boring No. MW-~~B2~~ D1

Page 7 of 16

START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
120									
122									
124									
126									
								SM	
128									
130				0.9/0		0924			
132									
134									
136									
138							Red coarse grain sand	SP	
140				1.4/0		0927			

LOG OF DRILLING OPERATIONS

Boring No. MW-~~02~~ D1

Page 8 of 16

START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BI / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
140									
142									
144									
146								SP	
148									
150				1.5/0		0952			
152									
154									
156									
158							Very Pale Brown Silt	ML	
160				0.7/0		0959			

LOG OF DRILLING OPERATIONS

Boring No. MW-~~B2~~ D1

Page 9 of 16

START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
160									
162									
164									
166									
168								MC	
170				0/0		1039			
172									
174									
176									
178									
180				0/0		1046			

LOG OF DRILLING OPERATIONS

Boring No. MW-~~DD~~ D1
Page 10 of 16

START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
180									
182									
184									
				0/0		1105			
186									
188								ML	
190				0/0		1108			
192									
194									
				0/0		1112			
196									
198									
200				0/0		1129			

LOG OF DRILLING OPERATIONS

Boring No. MW-~~??~~ D1
Page 11 of 16

START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
200									
202									
204									
				6/0		1133			
206									
208								SM	
							Dark Yellowish Brown silty Sand		
				0/0		1138			
210									
212									
214									
				0/0		1142			
216									
218									
220				0		1145			

LOG OF DRILLING OPERATIONS

Boring No. MW-~~B~~ D1

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START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
220									
222									
224									
				0/0					
226									
								SM	
228									
230				0/0		1340			
232									
234									
				0/0		1345	Reddish Brown Sandy Silt	ML	
236									
238									
240				0/0		1357			

LOG OF DRILLING OPERATIONS

Boring No. MW-~~[illegible]~~ D1

START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
240									
242									
								ML	
244				0/0		1401			
246									
248									
250				0/0		1405	Drilling Fast. Not even hitting hammer at times and casing dropping 6 inch to a Foot at a time.	SP	
252									
254									
				0/0		1408	Yellowish Red coarse grained Sand		
256									
258									
260				0/0		1414			

LOG OF DRILLING OPERATIONS

Boring No. MW-~~B2~~ D1
Page 14 of 16

START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
260									
262									
264									
				0/0		1416			
266									
268									
270								SP	
				0/0		1419			
272									
274									
276				0/0		1421			
278									
280						1423			

LOG OF DRILLING OPERATIONS

Boring No. MW-~~02~~ D1
Page 15 of 16

START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
280									
282									
284									
286									
288							From 280 - 300 hammer was never used. Casing went down as bit advanced	SP	
				0/0		1430			
290									
292									
294									
296									
298									
300				0/0		1431			

LOG OF DRILLING OPERATIONS

Boring No. MW-~~02~~ D1
Page 16 of 16

START DATE 2-4-99 GEOLOGIST D. Perry

Depth Below Surface (ft)	Sample Interval	Core Run/ Recovery	Field Sample ID	BH / BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
300									
302									
304								SP	
306							300-320. Did not need to use hammer. Casing followed bit. 20 Feet in less than 1 minute.		
308									
310									
312									
314									
316							Dark Reddish Gray Coarse Sand	SP	
318									
320				0/0		1443			
325						1450	Bottom of Hole		

APPENDIX B

Material Safety Data Sheets

MATERIAL SAFETY DATA SHEET

GREAT WESTERN CHEMICAL COMPANY

ISSUE DATE: 03/05/97	SUPERSEDES: 03/01/94
GREAT WESTERN MSDS NUMBER: 91246	

NFPA 704 DESIGNATION
HAZARD RATING

4 = Extreme
3 = High
2 = Moderate
1 = Slight
0 = Insignificant

Fire: 0
Health: 2
Reactivity: 1
Special: OX

1. CHEMICAL PRODUCT IDENTIFICATION & COMPANY IDENTIFICATION

PRODUCT IDENTIFIER: HYDROGEN PEROXIDE 35%

GENERAL USE: Used as a bleaching agent, a refining agent for oils and fats, and as a hypo eliminant in photography. Used in the plastics and microelectronic industries.

PRODUCT DESCRIPTION: An inorganic peroxide. Synonyms include: Dihydrogen dioxide, hydroperoxide, Albone, Hioxyl.

INFORMATION PROVIDED BY:

GREAT WESTERN CHEMICAL COMPANY
Corporate Office
808 S.W. 15th Avenue
Portland, OR 97205
PHONE: 503-228-2600 FAX: 503-221-5767

EMERGENCY PHONE NUMBERS

GREAT WESTERN:	800-497-7455
CHEMTREC:	800-424-9300
CANUTEC:	613-996-6666

2. COMPOSITION & INFORMATION ON INGREDIENTS

COMPONENT	CAS #	OSHA HAZARD	Wt.%	ACGIH TLV (TWA)	ACGIH STEL	OSHA PEL (TWA)	OSHA STEL
Hydrogen Peroxide	007722-84-1	Oxidizer, Corrosive, Lung Toxin	35 Minimum	1 ppm	None	1 ppm	None

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW:

A clear, colorless liquid with a sharp odor. Vapors, mist and liquid are corrosive and can cause severe irritation to eyes, skin, nose, mouth, throat and respiratory tract. Product will not burn, but decomposition will release oxygen, which will increase the explosive limits and burning rate of flammable vapors.

POTENTIAL HEALTH EFFECTS:

INHALATION: Exposure to vapors or mists may be severely irritating to the respiratory tract. Pulmonary edema may develop and can result in shortness of breath, wheezing, choking, chest pain and impairment of lung function. Effects may be delayed for several hours.

EYE CONTACT: Exposure to vapors, mists or liquid may cause severe eye irritation or burns. Symptoms of exposure may include: blurred vision, redness, watering, a burning sensation, and swelling. Direct contact of liquid may cause impairment of vision and corneal damage.

SKIN CONTACT: Exposure to vapors, mists or liquid may cause severe skin irritation or burns. Symptoms of exposure may include: a tingling sensation, redness, swelling, and whitening of the skin. Prolonged skin exposure may cause destruction of the dermis with ulceration.

INGESTION: Ingestion may cause severe irritation or burns to the gastrointestinal tract. Symptoms of exposure may include: nausea, vomiting, diarrhea, abdominal pain, bleeding, and/or tissue ulceration. Ingestion causes severe damage to the gastrointestinal tract with the potential to cause perforation.

CHRONIC: Chronic exposure may cause bleaching of the hair and an impairment of lung function.

CONTINUED ON PAGE 2

4. FIRST AID MEASURES

INHALATION: If inhaled, immediately move to fresh air. If not breathing, give artificial respiration, preferably mouth to mouth. If breathing is difficult, give oxygen. Call a physician.

EYE CONTACT: In case of contact, immediately flush eyes with plenty of clean running water for at least 15 minutes, lifting the upper and lower lids occasionally. Remove contact lenses, if worn. Call a physician immediately.

SKIN CONTACT: In case of contact, immediately flush skin with plenty of clean running water for at least 15 minutes, while removing contaminated clothing and shoes. If burn or irritation occurs, call a physician.

INGESTION: If swallowed, **DO NOT** induce vomiting. Get medical attention immediately. If victim is fully conscious, give plenty of water to drink. Never give anything by mouth to an unconscious person.

NOTE TO PHYSICIANS: Delayed pulmonary edema can occur after several hours.

5. FIRE FIGHTING MEASURES

Flashpoint and Method: Not flammable.

Flammable Limits (In air, % by volume): **Lower:** Not applicable **Upper:** Not applicable

Autoignition Temperature: Not applicable

GENERAL HAZARD: The Uniform Fire Code physical hazard rating for this product is: **Oxidizer Class 2.** This product is not flammable, but thermal decomposition will release oxygen, which will increase the explosive limits and burning rate of flammable vapors. Product may produce hazardous fumes or hazardous decomposition products.

FIRE FIGHTING INSTRUCTIONS: **EXTINGUISING MEDIA:** Use water only.
Use water to cool containers exposed to fire.

Flood fire area with water only.

FIRE FIGHTING EQUIPMENT: Fire fighters should wear full protective equipment, including self-contained breathing apparatus.

HAZARDOUS COMBUSTION PRODUCTS: Oxygen.

6. ACCIDENTAL RELEASE MEASURES

LAND SPILL: Remove all combustible materials. Wearing recommended protective equipment and clothing, dike spill and pick up bulk of liquid using non-sparking tools or absorb liquid in sand or a non-combustible absorbent. Place in approved containers for disposal or satellite accumulation. **CAUTION: Oxidizer wastes are not to be mixed with any other substances, including other oxidizers.** Flush spill area with water; collect rinsates for disposal or sewer, as appropriate.

WATER SPILL: Wear protective equipment and clothing if contact with hazardous material can occur. Stop or divert water flow. Dike contaminated water and remove for disposal and/or treatment. As appropriate, notify all downstream users of possible contamination.

7. HANDLING AND STORAGE

STORAGE TEMPERATURE: Store below 38 °C (100 °F) **STORAGE PRESSURE:** Ambient

GENERAL:

Store in a cool, dry, well-ventilated place, away from ignition sources or heat sources. Do not expose to direct light. Store in vented containers. This product can be potentially explosive if contaminated with other chemicals. Separate from readily oxidizable materials and catalytic metals. This product is an oxidizer which may liberate oxygen and promote combustion of flammable materials. Avoid concentrating hydrogen peroxide by removal of water. Drying of product on combustible material may cause fire or explosion.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

CONTROL MEASURES: Use local mechanical exhaust ventilation capable of maintaining emissions in the work area below the PEL or TLV.

RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT:

RESPIRATOR: For exposure above the PEL or TLV, a NIOSH-approved full facepiece respirator with supplied air or a self-contained breathing apparatus is required.

EYES: Wear chemical goggles (recommended by ANSI Z87.1-1979), unless a full facepiece respirator is worn.

GLOVES: Neoprene, nitrile or rubber gloves.

CLOTHING & EQUIPMENT: Wear a rubber or PVC slicker suit when handling product. An eyewash station and safety shower should be available in the work area.

FOOTWEAR: Neoprene or rubber boots.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	Clear, colorless	**Bulk Density (pounds/ft^3):**	Not applicable
Physical State:	Liquid	**Vapor Pressure:**	23 mm Hg @ 30 °C
Odor:	Sharp	**Vapor Density (air=1):**	No data available
Odor Threshold:	No data available	**Evaporation Rate (n-Butyl Acetate=1):**	Less than 1
Molecular Formula:	H_2O_2 (in water)	**VOC Content:**	None
Molecular Weight:	34.02 (in water)	**% Volatile:**	100
Boiling Point:	108 °C (226 °F)	**Solubility in H_2O:**	Complete
Freezing/Melting Point:	-32.2 °C (-26 °F)	**Octanol/Water Partition Coefficient:**	No data available.
Specific Gravity:	1.1327 @ 18 °C	**pH (as is):**	3.0
Density (pounds/gallon):	9.44	**pH (1% solution):**	3.1 to 4.5

10. STABILITY AND REACTIVITY

GENERAL: This product is stable and hazardous polymerization will not occur.

CONDITIONS TO AVOID: Storage of product above 38 °C (100 °F).

INCOMPATIBLE MATERIAL: Do not expose material to iron, copper, chromium, brass, bronze, lead, silver, manganese or their salts, organic materials, or oxidizable materials.

HAZARDOUS DECOMPOSITION PRODUCTS: Oxygen.

SENSITIVITY TO MECHANICAL IMPACT: This product is not sensitive to mechanical impact.

SENSITIVITY TO STATIC DISCHARGE: This product is not sensitive to static discharge.

11. TOXICOLOGICAL INFORMATION

Components:	Hydrogen Peroxide
Eye Contact:	No data available
Skin Contact:	No data available
Oral Rat LD_{50}:	1518 mg/kg (8-20% solution)
Dermal Rabbit LD_{50}:	LDLo: 500 mg/kg
Inhalation Rat LC_{50}:	No data available
Human Data:	Oral man; LDLo: 2626 ug/kg
Other Toxicological Data:	Inhalation mouse; LCLo: 227 ppm
Carcinogenicity:	No data available
Teratogenicity:	No data available
Mutagenicity:	Hamster; lung: 1 mmol/l (30% solution)
Synergistic Products:	No data available
Target Organs:	Eyes, skin, Lungs
Medical Conditions Aggravated by Exposure:	Chronic respiratory or skin diseases

12. ECOLOGICAL INFORMATION

ENVIRONMENTAL FATE:
This material is heavier than water and completely soluble. No specific information on environmental fate of this product is available.

ENVIRONMENTAL EFFECTS:
Aquatic toxicity: TLM 96: 1-10 ppm. Coho Salmon: 10 ppm.

13. DISPOSAL CONSIDERATIONS

RCRA 40 CFR 261 CLASSIFICATION: Ignitable Waste

U.S. EPA WASTE NUMBER/DESCRIPTION: D001

If this product becomes a waste, it meets the criteria of a hazardous waste as defined under 40 CFR 261 due to its ignitability. If this product becomes a waste, it will be a hazardous waste which is subject to the Land Disposal Restrictions under 40 CFR 268 and must be managed accordingly. As a hazardous liquid waste, it must be disposed of in accordance with local, state and federal regulations in a permitted hazardous waste treatment, storage and disposal facility by incineration.

14. TRANSPORTATION INFORMATION

DOT PROPER SHIPPING NAME:	Hydrogen peroxide, aqueous solutions			
DOT HAZARD CLASS:	5.1			
UN NUMBER:	UN2014			
PACKING GROUP:	II			
DOT LABELS:	**Primary:** Oxidizer		**Subsidiary:**	Corrosive
DOT PLACARDS:	Oxidizer			
CERCLA Reportable Quantity:	None			
MARINE POLLUTANT:	No			
DOT 1993 Emergency Response Guidebook No.:		45		
DOT 1996 North American Emergency Response Guidebook No.:		140		
TDG PROPER SHIPPING NAME:	Hydrogen peroxide, aqueous solutions			
TDG HAZARD CLASS:	5.1 (8)	**Regulated Limit (RL):** Not applicable		
UN NUMBER:	UN2014			
PACKING GROUP:	II			
TDG LABELS:	**Primary:** Oxidizer		**Subsidiary:**	Corrosive
TDG PLACARDS:	Oxidizer			
CANUTEC Initial Emergency Response Guide Number:		30		
Other Shipping Information:	None.			

15. REGULATORY INFORMATION

COMPONENTS: Hydrogen Peroxide

OSHA

Target Organs: Eyes, Skin, lungs

Carcinogenic Potential:
- Regulated by OSHA: No
- Listed on NTP Report: No
- IARC Listing: No

U.S. EPA Requirements

Release Reporting

CERCLA (40 CFR 302):
- Listed Substance: No
  - Reportable Quantity: Not applicable
  - Category: Not applicable
  - RCRA Waste No.: Not Applicable
- Unlisted Substance: Yes
  - Reportable Quantity: 100 lbs
  - Characteristic: Ignitability
  - RCRA Waste No.: D001

SARA TITLE III

Section 302 & 303 (40 CFR 355)
- Listed Substance: No
  - Reportable Quantity: Not Applicable
  - Planning Threshold: Not applicable

Section 311 & 312 (40 CFR 370)
- Hazard Categories (product): Fire: Y Sudden Release of Pressure: N Reactive: N Acute Health: Y Chronic Health: Y
- Planning Threshold: Not applicable

Section 313 (40 CFR 372)
- Listed Toxic Chemical: Yes
  - Reporting Threshold: 10,000 lbs.

U.S. TSCA STATUS

Listed (40 CFR 710): Yes

CANADIAN REGULATIONS

Controlled Product: Yes
WHMIS Hazard Symbols: Oxidizing Material, Corrosive Material, Dangerously Reactive Material.
WHMIS Class & Division: C, E, F
Product Identification Number: UN2014
IDL Substance: Yes
Domestic Substance List: Yes
CEPA Priority List: No

Carcinogenicity:
- ACGIH Appendix A: No
- A1 Confirmed Human: No
- A1 Suspected Human: No
- IARC Group: Group 3

STATE REGULATIONS:

State of California

Safe Drinking Water and Toxins Enforcement Act, 1986 (Proposition 65)
- Carcinogen: No
- Reproductive Toxin: No

OTHER REGULATIONS:

State Right To Know Laws: MA, NJ, PA

PRODUCT IDENTIFIER: **HYDROGEN PEROXIDE 35%**

16. OTHER INFORMATION

EPA Registration number: Not Applicable

Approved Product Uses: Not Applicable

Special Notes:
n/a

MSDS Revision Information:

Form Revision made 02/03/94
Information Revised This Issue Date: **Updated MSDS, Canadian 3 year rule.**

MSDS distributed by **Great Western Chemical Company**
Environmental Department
Phone: 800-547-1400 FAX: 503-221-5767

Prepared By:	Becca Heartwell	**Date Prepared:**	March 5, 1997

APPENDIX C

Manufacturer's Specifications

Merckoquant® 1.10011.0001

Peroxide Test

Analytical test strips for the detection and semiquantitative determination of peroxides

General

The Peroxide Test detects inorganic and organic compounds which contain a peroxide or a hydroperoxide group. The test is therefore well suited for the routine control of simple ethers such as diethyl ether, tetrahydrofuran and dioxane. Polymeric peroxides which can under some circumstances form in simple ethers are not detected or only detected with reduced sensitivity. In such cases, a trial determination should be carried out in the laboratory to check the suitability of the peroxide test strip.

Apart from checking ethers, the test can also be used for checking UHT milk for residual peroxides, for determining perborates in washing powders, for checking electrolytic etching and copper stripping baths containing peroxides, for checking the concentration of peroxides added as bleaches or oxidants in paper and textile manufacture and for the determination of peroxides in swimming pool water.

Peroxide on its own and combined with peracetic acid is a versatile disinfectant which, because of its biocidal, fungicidal and virucidal properties and because it does not form harmful decomposition products, can even be used in the food industry. Here, the test is suitable for checking the prescribed concentration of disinfectant and residual concentration after disinfection, when equipment or the product must be washed free of disinfectant.

Method of determination

Peroxidase (POD) transfers oxygen from the peroxide to an organic redox indicator, which is then converted to a blue-coloured oxidation product.

In the case of organic solvents, the moisture required for the reaction is obtained by briefly dipping in distilled water or by repeatedly breathing on the reaction zone after dipping into the solvent.

Instructions for use

Aqueous solutions

1. Remove 1 test strip and immediately reclose the tube.
2. Dip the test strip into the solution to be tested for 1 sec, such that the reaction zone is completely wetted.
3. Remove the test strip, shake off excess liquid and compare the reaction zone with the colour scale after 15 sec.

Organic solvents (volatile ethers)

1. Remove 1 test strip and immediately reclose the tube.
2. Dip the test strip into the solvent to be tested for 1 sec, such that the reaction zone is completely wetted.
3. Move the test strip slightly to and fro for 3–30 sec until the solvent has evaporated from the reaction zone, then
   a) dip into distilled water for 1 sec, shake off excess water
   or,
   b) breathe on it 4 times each for 3–5 sec.
4. After 15 sec, compare the reaction zone with the colour scale.

Notes

The appearance of any blue coloration within 3 min can be interpreted as a positive reaction.

If a deep dark blue to brown colour or a green to brown colour is produced, the peroxide concentration is too high for the colour scale. In this case dilute with water or peroxide-free ether or petroleum ether (boiling range 40–60 °C) and test as in the Instructions for use.

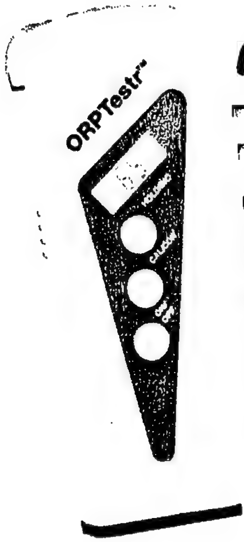
Inorganic peroxides are determined in aqueous solution at pH 2–12. (Measure the pH with non-bleeding Universal Indicator Strips pH 0–14.) If necessary adjust the pH of the solution with citric acid or hydrochloric acid 1 mol/l or with sodium citrate or sodium acetate.

For further information (e.g. interference by other anions and cations) please ask for our Merckoquant® leaflet.

Storage

Unopened packs of the Merckoquant® Peroxide Test should be stored in a refrigerator. Opened packs on the other hand must be stored as dry and as cool as possible, but outside the refrigerator since on repeated opening of the cooled pack so much moisture condenses in the tube that the capacity of the drying agent in the stopper is exceeded.

Merck KGaA, 64271 Darmstadt, Germany, Tel. (0 61 51) 7 20, Telefax (0 61 51) 72 20 00



ORPTESTR

- *Fast, stable, and repeatable readings*
- *Push-button calibration*

Use this versatile instrument for applications ranging from swimming pool testing to pulp bleaching. ORPTestr features ±5 mV accuracy and a ±150 mV offset. Platinum band cell is ideal for checking chromate reduction, cyanide oxidation, and other ORP readings.

Access all functions via the splashproof keypad—keys click to confirm operation. Hold function freezes readings. Auto-off function shuts tester off after 8½ minutes to extend battery life. Error messages alert you to low-battery status, overrange readings, or incorrect calibration.

Valox® body resists most chemicals. (**NOTE:** Do not immerse tester beyond the level line on the tester.) Sturdy pocket clip has two holes for attaching a lanyard. Powered by three 1.4 V batteries (included).

H-59001-00 ORPTestr......................**$95.00***

SPECIFICATIONS

Range: –50 to 1050 mV
Resolution: 5 mV
Accuracy: ±5 mV
Temperature compensation: no
Display: 3-digit LCD, 5⁄16"H
Power: three 1.4 V batteries (included)
Battery life: 100 hours
Dimensions: 5⅞"L x 1⅝"W x 1⁵⁄₁₆"H
Shpg wt: 1 lb (0.5 kg)

ACCESSORIES

SOFT CARRYING CASES

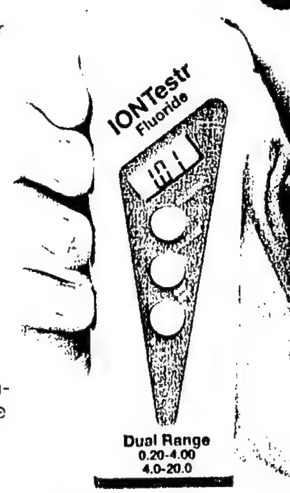
Use these cases for any combination of pH, ORP, or fluoride testers on pages 831-833 (excluding waterproof testers). Cases hold one, two, or three testers.

Cat. no.	Holds	Price
H-35624-41	One tester	$4.25
H-35624-42	Two testers	6.10
H-35624-43	Three testers	7.95

H-05941-05 Replacement batteries, 1.4 V. Pack of 12 ....**$12.50/pk**

NEW FLUORIDE TESTER

- *Fluoride measurements from a pocket-sized unit*



This new dual-range fluoride ion selective tester provides direct measurements of fluoride ion concentrations, yet is small enough to go anywhere! Choose between two ranges—0.20 to 4.00 ppm and 4.0 to 20.0 ppm.

Tester uses 0.50 ppm, 1.00 ppm, and 2.00 ppm fluoride standards in accordance with ASTM recommendations. Use it to measure fluoride in drinking, surface, and saline water as well as in domestic and industrial wastes.

All functions are accessible through the splashproof keypad. Keys produce an audible click to confirm operation. Valox® body resists most chemicals. Convenient clip and lanyard attachment let you keep tester handy while completing other tasks.

H-59001-10 Fluoride ion tester with electrode **$400.00**
H-59001-11 Replacement fluoride electrode......................**$150.00**

SPECIFICATIONS

Range: 0.20 to 20.0 ppm
Resolution
  0.20 to 4.00 ppm: 0.01 ppm
  4.0 to 20.0 ppm: 0.1 ppm
Accuracy
  0.50 to 4.00 ppm: ±0.05 ppm
  4.0 to 20.0 ppm: ±2% of measured value
Display: 3-digit LCD, 5⁄16"H
Power: four 1.4 V batteries (included)
Battery life: 50 hours
Dimensions: 5⅞"L x 1⅝"W x 1⁵⁄₁₆"H
Shpg wt: 1 lb (0.5 kg)

FLUORIDE TESTER CALIBRATION KIT

This calibration kit contains everything you need to begin testing. Kit includes one 250-ml bottle each of 0.50, 1.00, and 2.00 ppm fluoride standards; Total Ionic Strength Adjustment Buffer (TISAB); and distilled water for rinsing electrode. Accessories are packaged in a hard plastic carrying case that's large enough to hold everything plus a tester with electrode (tester and electrode not included).

H-59001-12 Calibration kit......................**$200.00**
H-59001-13 Replacement calibration solutions. One 250-ml bottle each of 0.50, 1.00, and 2.00 ppm fluoride standards **$30.00**
H-59001-14 Replacement TISAB solution, 250-ml bottle......................**$10.00**

NEW POCKETFET pH TESTER

- *It's a pocket-sized pH meter that uses ISFET technology*
- *Requires only a drop of sample to take a measurement*

This new solid-state PocketFet pH tester features ion-selective field effect transistor (ISFET) technology—there's no fragile glass electrode bulb. PocketFet is easy to maintain—just wipe clean and store dry. Use it in the lab or field at temperatures from 5 to 40°C (41 to 105°F).

Measure the pH of semisolid, viscous, and aqueous samples by simply dipping the tip of the tester into the sample. To monitor the pH of microdialysis samples, chromatography fractions, and other small-volume samples, just put a drop of the sample on the sensor. (PocketFet is not recommended for use with organic solvents, in direct sunlight, or in excessive temperatures.)

PocketFet has a unique on/off photo sensor that conserves battery life. An LED warning light flashes when batteries need to be changed.

H-59100-30 PocketFet pH tester......................**$199.00**
H-09376-17 Replacement batteries, 3 V. Pack of six **$13.25/pk**

SPECIFICATIONS

Range: pH 2.0 to 12.0
Accuracy: ±0.1 pH unit
Temperature compensation: no
Power: two 3 V lithium batteries (included)
Dimensions: 5⅝"L x 1"W x ⅜"H
Resolution: 0.1 pH unit
Calibration: two- or three-point
Display: 3-digit LCD, 5⁄16"H
Battery life: 200 hours
Shpg wt: 1 lb (0.5 kg)

***DISCOUNT**: Save 10% when you purchase 12 or more ORPTestrs.

Valox—Reg TM General Electric Co.

Cole Parmer

Model 59001-00

ORPTestr™

Microprocessor Based Pocket Size ORP Tester

BEFORE FIRST USE: Remove plastic strips between batteries and contacts if present (see box side panels). Do not be alarmed if white crystals form around the cap. They are normal and will dissolve during CONDITIONING.

CAUTION: TO AVOID CROSS CONTAMINATION BETWEEN SAMPLES, NEVER IMMERSE THE ELECTRODE ABOVE THE COLOR BAND!

CONDITIONING: Before first use, remove cap and rinse the electrode in water to dissolve any crystals and activate the electrode.

CALIBRATION: Calibration is not necessary unless exact readout agreement with a work standard and at a specific ORP value is needed. To achieve this, use the following procedure:

Select a solution sample from the actual process as near the critical ORP value as possible. Dip the electrode from the work standard and the conditioned ORPTestr into this solution for 2 to 5 minutes until the readings stabilize. Note the reading of the standard.

Press the ORPTestr CAL/CON button. Display will flash "CA", then the ORP reading. If work standard reading is higher, press the HOLD/INC button until the display reads the same value as the work standard. If work standard reads lower, continue pressing the HOLD/INC button until the value displayed scrolls around to the standard's value. Press CAL/CON. "CO" is displayed and offset adjustment is complete. This offset adjustment defaults to factory calibration when batteries are removed/replaced.

ORP TESTING

- Remove cap. Press ON/OFF button to turn on.
- Dip the electrode ½" to 1" into test solution and stir once.
- Allow the reading to stabilize 2 to 5 min.
- Press "HOLD" button if you wish to hold the reading ("HO" will be displayed momentarily). Press it again to release it ("HC" will be displayed momentarily).
- Press the ON/OFF button to shut off.
- THERE IS AN AUTOMATIC SHUT-OFF AFTER 8.5 MINUTES TO CONSERVE BATTERIES!

CHANGING BATTERIES: Flip up battery compartment lid (see box side panels). Replace batteries with fresh ones noting polarity as shown in battery compartment.

SPECIFICATIONS

Range	-50 to +1050 mV
Resolution	5 mV
Accuracy	±5 mV repeatability
Offset Adjust.	±150 mV—brings ORP into agreement with your work standard.
Operating Temp.	32 to 122°F, 0 to 50°C,
Battery/Life	3pcs. 1.4V Eveready EP675HP/ 100 hrs (Silver Oxide battery may be substituted; use model 303. Typical life=70 hrs.)
Wetted Materials	glass, platinum, glass reinforced thermoplastic polyester
Size (meter only)	5.9"L x 1.65"W x 0.94"H
Wt. (meter only)	3.25 oz. (92 gm)

SEE SIDE PANEL FOR ERROR MESSAGE EXPLANATIONS!

NEW YSI DISSOLVED OXYGEN METERS

- Built-in calibration chamber
- Splashproof IP65 housing

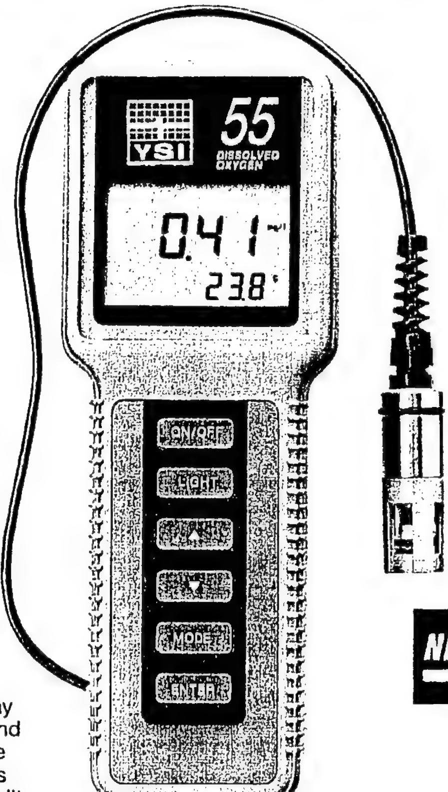
These new ruggedly constructed dissolved oxygen meters offer long-lasting service. They're great for environmental testing, wastewater treatment, fish farming, research laboratories, or any application where DO spot testing is required. Each meter features a durable stainless steel probe that sinks easily into water. Probes come with a strain relief spring to protect cable against flexing and tugging.

Built-in calibration chamber makes field calibration quick and easy. Chamber houses a small sponge that can be moistened with distilled water to provide a 100% water-saturated air environment for calibrating, transporting, and storing probe. To calibrate, simply wet sponge, insert probe into chamber, enter altitude and salinity values, and measure. Automatic barometric pressure and salinity correction ensure accurate results—eliminates the need for cumbersome charts.

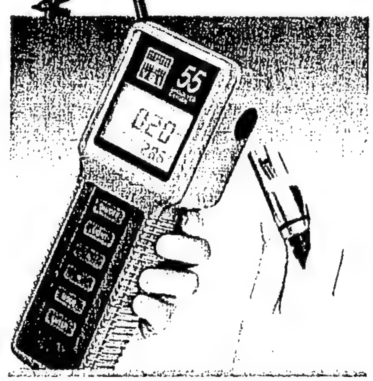
Meters simultaneously measure and display both oxygen (in mg/l or % air saturation) and temperature (in °C). Automatic temperature compensation ensures accuracy. All results are conveniently displayed on a large, backlit LCD—great for use in dark or poorly lit areas.

Choose meters with 12- or 25-ft cables. Both models include 30 membranes, one bottle of KCl solution, six AA batteries, a convenient carrying strap, and an instruction manual.

H-53010-00 Dissolved oxygen meter with probe and 12-ft cable **$875.00**
H-53010-10 Dissolved oxygen meter with probe and 25-ft cable **$895.00**
H-05522-00 Replacement membrane kit includes 30 standard membranes and 5.25 g of KCl crystals **$16.00**
H-09376-01 Replacement batteries, 1.5 V AA. Pack of four.................................**$3.30/pk**



Rugged construction is perfect for field use!

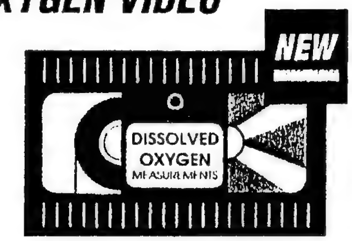


SPECIFICATIONS

Range	Resolution	Accuracy
0 to 20 mg/l	0.01 mg/l	±0.3 mg/l
0 to 200% saturation	0.1% saturation	±2%
−5.0 to 45.0°C	0.1°C	±0.4°C

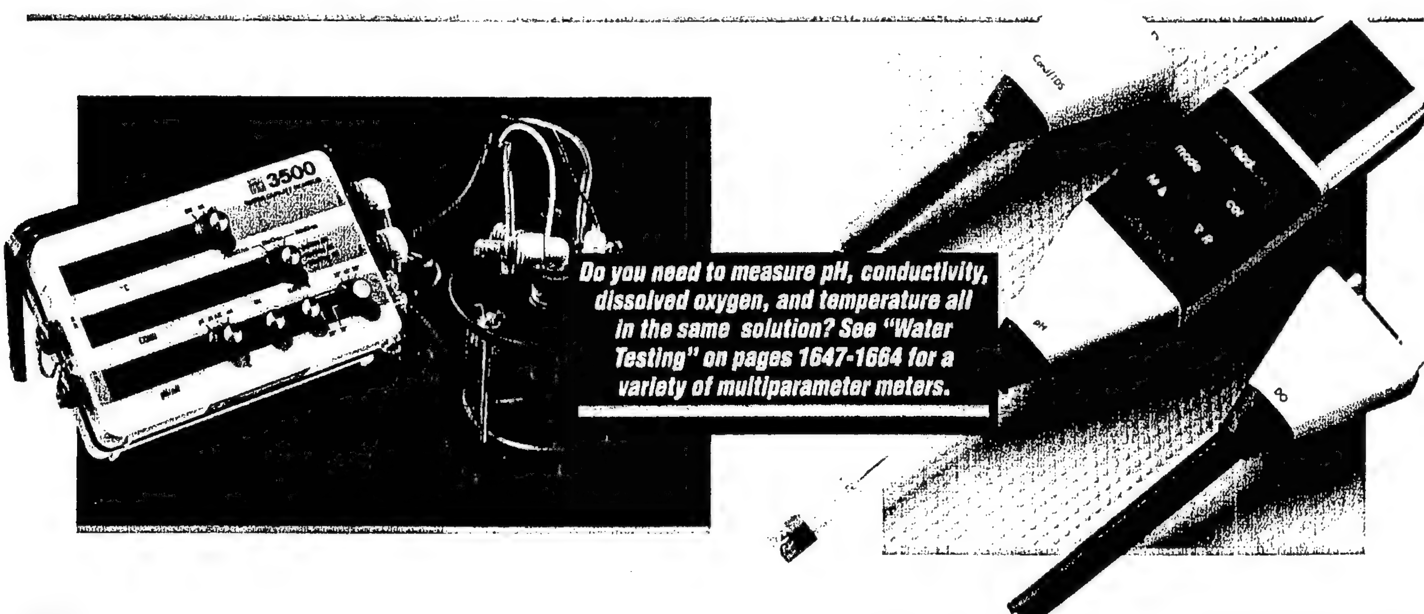
Salinity compensation: manual from 0 to 40 ppt
Altitude compensation: manual from 0 to 10,000 ft
Probe: polarographic
Display: 3½-digit LCD
Operating ambient: 23 to 113°F (−5 to 45°C)
Power: six 1.5 V AA batteries (included)
Battery life: approximately 100 hours of continuous operation
Dimensions: 3½"W x 9½"H x 2¼"D
Shpg wt: 2 lbs (0.5 kg)

NEW YSI DISSOLVED OXYGEN VIDEO

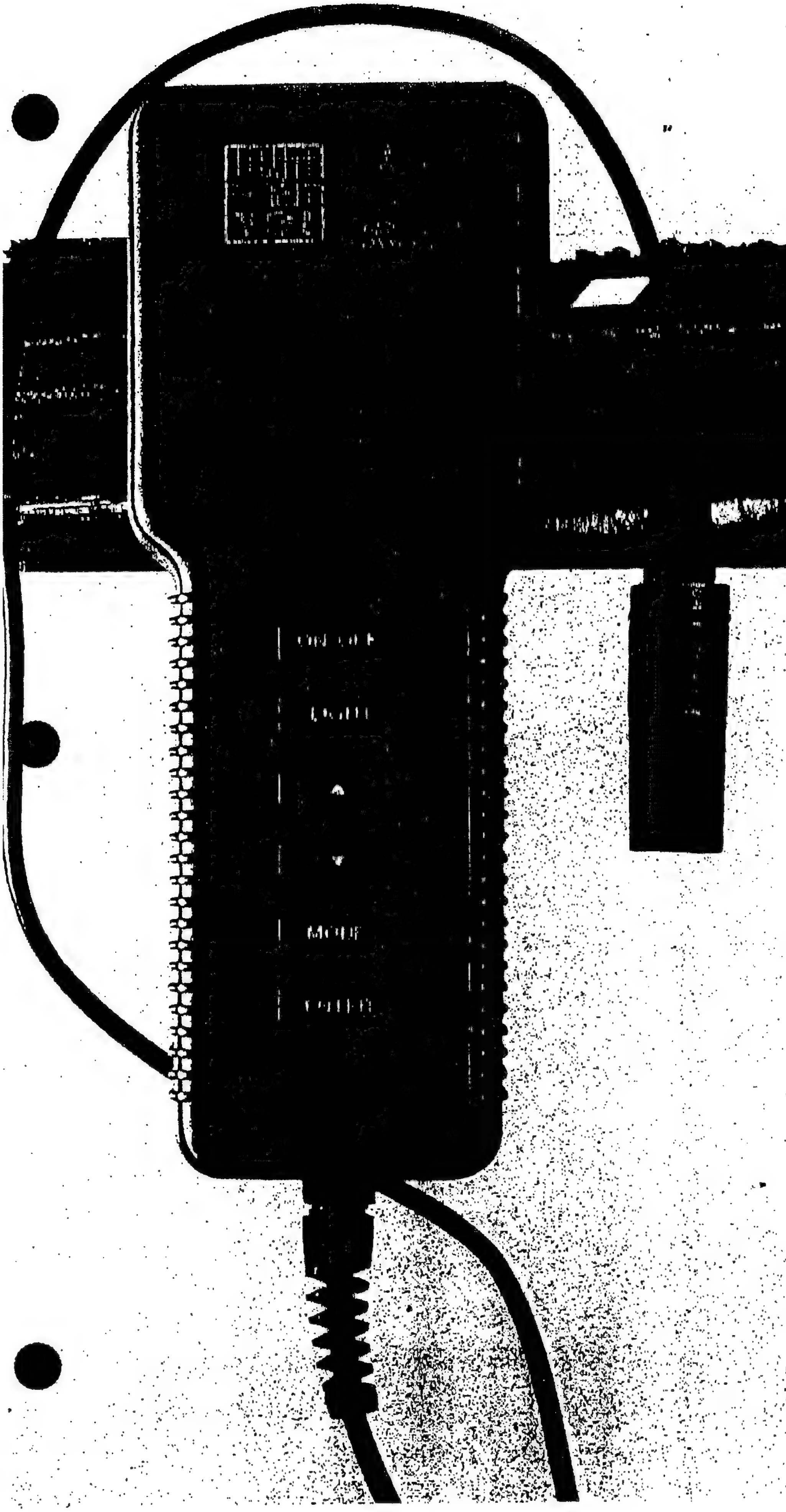


This new dissolved oxygen instructional video contains everything you ever wanted to know about taking DO measurements. Video introduces the basic concepts of dissolved oxygen and discusses simple calibration and operating procedures. Also covers troubleshooting techniques.

H-05528-00 Dissolved oxygen measurement, VHS **$36.50**



Do you need to measure pH, conductivity, dissolved oxygen, and temperature all in the same solution? See "Water Testing" on pages 1647-1664 for a variety of multiparameter meters.



New Handheld Dissolved Oxygen System

The YSI 55 is a complete system for measuring dissolved oxygen

- Handheld meter
- 12' or 25' cable
- YSI probe with stainless steel body that sinks easily
- Pushbutton calibration
- Simultaneous display of oxygen and temperature
- Meter reads mg/L or % oxygen
- Direct salinity compensation
- Strain relief protects cable
- Built-in calibration chamber
- Large backlit display
- Low battery indicator

YSI

Easy Pushbutton Calibration

1 Remove probe from built-in calibration chamber.

2 Push calibration button, then indicate altitude.

3 Indicate salinity. Now you're ready to measure.

System Specifications

Accuracy
±0.3 mg/L
±2% air saturation
±0.4°C

Range
0-20 mg/L
0-200% air saturation
-5 to +45°C oxygen temperature

Resolution
0.01 mg/L dissolved oxygen
0.1% air saturation
0.1°C

Salinity Compensation
0 to 40 PPT

Altitude Compensation
0 to 10,000 feet

Power
6 AA alkaline cells provide approximately 100 hours of operation.

How to Order

Meter, probe with 12-foot cable

Meter, probe with 25-foot cable

Model 55/12
$850.00

Model 55/25
$895.00

YSI

APPENDIX D

Site-Specific Spill Plan

EM REVIEW/APPROVAL: ______________

SITE-SPECIFIC SPILL PLAN

DATE: 1/20/00 FACILITY NO.:

Aggressive Remediation Strategy, OU B

SITE DESCRIPTION:

Aggressive Remediation Strategy, OU B

ON-BASE SPILL DISCOVERY AND NOTIFICATION PROCEDURES

REPORT SPILL OR POTENTIAL RELEASE OF:

— Any quantity of an extremely hazardous substance (EHS)
— 1 lb/1 pint or more of a hazardous substance
— Any quantity if fire or health hazard is present

REPORT IMMEDIATELY TO:
McCLELLAN FIRE DEPARTMENT
911 or 643-6666

ACTIONS TO TAKE:

— Alert Personal – Evacuate if necessary.
— Information to report to Fire Dept:
  - Your name and phone number
  - Location of spill
  - Substance spilled
  - Estimated amount spilled
  - Extent of spill
  - Other pertinent information (e.g., injuries)
  - Isolate the spill area and follow site-specific procedures

SITE RESPONSIBLE INDIVIDUALS:	NAME	ORG. SYMBOL	PHONE NO.
Radian International Project Health & Safety Coordinator:	Kim Worl	Radian	(916) 857-7458
Supervisor:	Elise Willmeth	Radian	(916) 857-7330
Area Monitor:	TBD	Radian	TBD

OIL AND HAZARDOUS SUBSTANCE DATA (Indicate if Material [M] or Waste [W]):

Description	Quantity Amount/Unit	Type of Container	Waste Stream No. (if any)
(W) Decontamination Fluids	50 gallons	55-gallon drum	Contaminated water
(M) 10% Hydrogen Peroxide	2,000 gallons	Tank with secondary containment	None

MSDS LOCATION: Inside JV Field Trailer

Available with the area monitor

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SITE-SPECIFIC SPILL PLAN (continued)	FACILITY NO: Aggressive Remediation Strategy, OU B

EVACUATION PROCEDURES:

1. Notify all personnel at the Aggressive Remediation Strategy study area to clear the danger area as necessary to avoid injury.
2. Maintain the cleared area until the site is safe.
3. Ensure secondary containment is containing the spill.

ON-SITE PERSONAL PROTECTIVE/SAFETY EQUIPMENT:	**ON-SITE SPILL CLEANUP KIT:**
Chemical-resistant gloves	Absorbent (e.g., kitty litter)
Chemical-resistant jacket worn over sturdy work clothing	Square point D handle shovel
Safety glasses and face shields	Disposal drum
Chemical-resistant steel-toed boots	Push broom
Half-face respirators	

SITE-SPECIFIC PROCEDURES:

1. Alert site supervisor and personnel; evacuate all personnel who are not equipped with personal protective equipment.
2. Notify base fire department, 911 (or 3-6666). Also notify the Maintenance Control Center, LAPRP, 3-3780.
3. Make spill scene off limits to unauthorized personnel.
4. If advised by the on-site commander, contain/cover spilled liquids with absorbent. Place absorbent, spill residue, and contaminated soil in a disposal drum.
5. Notify the Project Health and Safety Officer (HSO) to participate in the chemical spill mishap reporting. Obtain from the HSO the recommended preventative action to be taken to avoid future spills. Assure with the HSO that the proper procedures are followed. Initiate AFLC Form 5023, Supervisor's Preliminary Report of Mishap Notification and Reporting, for all spills. Ensure all information has been provided and obtain HSO coordination.

Notify the Contracting Officer (Capt. Robert Williams); Field Team Leader (Paul Bernheisel), and the McClellan AFB remedial project manager (Jim Lu).

SECONDARY CONTAINMENT:

A single-walled container with secondary containment will be stored on site. The tank will be located in a depression or dikes will be dug around the tank so that if there is any leakage, it will remain at the tank and not run off toward storm drains.

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RESPONSES TO COMMENTS ON THE DRAFT FINAL AGGRESSIVE REMEDIATION STRATEGY WORK IMPLEMENTATION PLAN, McCLELLAN AFB

Comment Number	Page	Section	Paragraph	Line	Reviewer	Comment	Response
Draft Final Work Implementation Plan Aggressive Remediation Strategy (DSR #385-3), McClellan Air Force Base, Sacramento County							
1.					James Taylor, RWQCB	Response to Comments, response to Comment 2, page 29: The response states that a go/no go decision logic has been added to the Draft Final Plan to address whether or not to proceed with this test based on the actual field conditions at the test site. Please provide a description of where this information is located in the Plan, as we could not locate it. While the response addresses our concern regarding the selection of the location for the in situ oxidation test, it fails to address our reservations that the resulting data can be conclusively evaluated. Please address this concern. If not addressed in the Response to Comments, we believe that this concern should be addressed at the time the go/no go decision logic is applied to the actual field conditions at the test site. The agency remedial project manager's should be consulted on the determination of whether or not to proceed with this test based on the actual field conditions at the test site (i.e., a go/no go decision).	The go/ no go decision logic was revised and specific language added to section 5.2.3. A flow diagram has been added to more clearly show the logic that will be used to determine if the test will be performed or not. We agree that changes in TCE concentration during the *in situ* oxidation test may be due to factors other than the injection of peroxide such as air sparging. Therefore, the results of the *in situ* oxidation test will be compared to results from another treatability test performed in OU A at McClellan AFB in which air sparging was performed in addition to the injection of propane. The air sparging done at the OU A treatability site was continuous rather than intermediate and the test was performed for a longer period of time. However, the results will be interpolated to determine the amount of effect that air sparging will have on the *in situ* oxidation test area. This discussion has been added to Section 5.3.

RESPONSES TO COMMENTS ON THE DRAFT FINAL AGGRESSIVE REMEDIATION STRATEGY WORK IMPLEMENTATION PLAN, McCLELLAN AFB

Comment Number	Page	Section	Paragraph	Line	Reviewer	Comment	Response
EPA Review Comments (DSR Record #385-4) on the draft final Aggressive Remediation Work Plan							
1.		General			Jeff Raines, TLI	It appears that the Air Force has responded adequately to this comment. It still seems that the in-situ oxidation test could be conducted in an area at the site where pump tests have already been conducted (e.g., near EW 366). However, the Air Force has determined that the selected location is the best available location to conduct the test and additional data is needed to model groundwater conditions at the site.	No response needed.
2.		Specific Comments			Jeff Raines, TLI	The Air Force response to this comment is not adequate. The Air Force indicates in the response to comments that Section 2.1 was revised to provide the logic used to select the site for the test. However, Section 2.1 was not modified to provide this decision logic. The original comment suggested that it would require fewer groundwater analyses to determine if in-situ oxidation was working if the Air Force selected an area with higher VOC concentrations to conduct the test. It appears that the Air Force has addressed this concern by allowing for a "fuzzy" assessment of the data should statistical methods fail. In addition, the Air Force does not have any groundwater quality data from the area proposed for the test. The closest A-Zone well to the test area (MW-164) produced	The go/ no go decision logic has been revised and specific language added to section 5.2.3. A flow diagram has been added to more clearly show the logic that will be used to determine if the test will be performed or not. This decision logic includes the criteria that the sampling strategy for *in situ* oxidation must achieve DQOs based on the contamination observed in the newly installed wells at the test site.

RESPONSES TO COMMENTS ON THE DRAFT FINAL AGGRESSIVE REMEDIATION STRATEGY WORK IMPLEMENTATION PLAN, McCLELLAN AFB

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2. (cont'd)					Jeff Raines, TLI	groundwater with a TCE concentration of only 25 µg/L during the 4th quarter of 1999. The Air Force should, at the very least, determine if the VOC in the groundwater at the test location is sufficiently contaminated to provide a meaningful test of in-situ oxidation prior to expending a significant amount of resources on this test.	
3.					Jeff Raines, TLI	The Air Force appears to have responded adequately to this comment.	No response needed.
4.					Jeff Raines, TLI	The Air Force appears to have responded adequately to this comment.	No response needed.
5.					Jeff Raines, TLI	The Air Force appears to have responded adequately to this comment.	No response needed.

RESPONSES TO COMMENTS ON THE DRAFT FINAL AGGRESSIVE REMEDIATION STRATEGY WORK IMPLEMENTATION PLAN, McCLELLAN AFB

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6.					Jeff Raines, TLI	The Air Force may not have responded adequately to this comment. The original comment was: It is our understanding that In-Situ Oxidation (ISO) requires a slightly acidic pH in groundwater to be effective. The work plan does not appear to discuss aquifer buffering to assure that conditions are right for ISO. Please revise the work plan to discuss the necessary aquifer pH for ISO and how the Air Force will assure that this condition is met. The Air Force response was that it did not believe that reducing pH would be wise as that might mobilize metals in the subsurface. TechLaw consulted with Professor Richard Valentine of the University of Iowa on this subject. Professor Valentine is currently conducting several studies for U.S. EPA regarding the use of Fenton's reaction to destroy organics in groundwater. Professor Valentine offered the following information, which was sent via e-mail, so it is informal, and is paraphrased below:	The pH of the aquifer will not be adjusted because the potential is too great that adverse chemical reactions will occur such as the release of metal species. Although the Fenton's reagent process does not produce hydroxyl radicals as efficiently under conditions of a higher pH, the reaction does occur as attested to by previous implementations of this technology performed by the vendor at other sites. The vendor also has performed a number of in situ oxidation bench studies that support this conclusion. Further, previous studies of natural attenuation in Northern Operable Unit C have demonstrated that the concentrations of ferrous iron in the groundwater at McClellan AFB should be sufficient to promote the Fenton's reagent process without the addition of an iron salt catalyst to the peroxide solution. This discussion along with appropriate references have been added to Section 5.3.

RESPONSES TO COMMENTS ON THE DRAFT FINAL AGGRESSIVE REMEDIATION STRATEGY WORK IMPLEMENTATION PLAN, McCLELLAN AFB

Comment Number	Page	Section	Paragraph	Line	Reviewer	Comment	Response
6. (cont'd)					Jeff Raines, TLI	Adjustment of pH generally is required and is important. The Fenton chemistry generally involves reaction of hydrogen peroxide with ferrous and ferric iron IN SOLUTION (a redox cycle). That is, the iron generally needs to be solubilized. At pH 3 the iron is soluble. At pH 7 it isn't. If enough iron (I assume they are adding ferrous not ferric salts?) the pH may become as low as 3. If the pH is maintained high, the main remedial action comes from the initial soluble ferrous iron being oxidized to ferric, then the ferric precipitates. Hydrogen peroxide will react with precipitated ferric hydroxide but it does not produce hydroxyl radicals very efficiently. It produces mostly oxygen. If they add enough hydrogen peroxide they will get some contaminant degradation but I cannot tell you how much. It is possible to get quite a bit but it will be expensive. It will definitely be a lot less efficient at the higher pH. I suggest a test at the exact concentrations of iron and hydrogen peroxide with real water to determine actual pH.	

RESPONSES TO COMMENTS ON THE DRAFT FINAL AGGRESSIVE REMEDIATION STRATEGY WORK IMPLEMENTATION PLAN, McCLELLAN AFB

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6. (cont'd)					Jeff Raines, TLI	Let me also recommend two of my papers that discuss hydrogen peroxide decomposition and contaminant oxidation in the presence of sand and several iron oxides all at neutral pH. Both were done with my students. Neutral pH is a whole different system than at low pH. At low pH, iron solubilization occurs and the reactions are not really surface catalyzed anymore. They can, however, be quite efficient at low pH if not very fast (rate vs. extent is another issue because you pay for extent/efficiency while rate deals more with delivery issues). At neutral pH, they are not generally very efficient although perhaps some contaminants with "special" properties might react faster. The papers are: Valentine, Richard L. and Wang, H.C. "Iron Oxide Surface Catalyzed Oxidation of Quinoline by Hydrogen Peroxide," Journal of Environmental Engineering (ASCE), 1998, Vol.124 (1); 31-38.	

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Comment Number	Page	Section	Paragraph	Line	Reviewer	Comment	Response
6. (cont'd)					Jeff Raines, TLI	Miller, Christopher, and Valentine, Richard L. "Mechanistic Studies of Surface Catalyzed H-2O2 Decomposition and Contaminant Degradation in the Presence of Sand," Water Research, Vol. 33, No. 12 (August), 1999, pp. 2805-2816. While mobilization of metals is a concern, Professor Valentine has raised issues regarding how well the in-situ oxidation will work. Professor Valentine's suggestion to perform a bench-scale test using site water prior to conducting the full-scale field test seems like a good one. Please revise the work plan to discuss the feasibility of conducting bench-scale testing prior to conducting the full-scale field test.	
7.					Jeff Raines, TLI	The Air Force appears to have responded adequately to this comment.	No response needed.
8.					Jeff Raines, TLI	The Air Force appears to have responded adequately to this comment.	No response needed.
9.					Jeff Raines, TLI	The Air Force appears to have responded adequately to this comment.	No response needed.
10.					Jeff Raines, TLI	The Air Force appears to have responded adequately to this comment.	No response needed.
11.					Jeff Raines, TLI	The Air Force appears to have responded adequately to this comment.	No response needed.